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# TABLE OF CONTENTS.*

## *Publications* No. 27, January 1, 1893.



## *Publications* No. 28, January 28, 1893.



* To the Binder: this should precede page 1, Volume V.

*Publications* No. 29, March 25, 1893.

## *Publications* No. 30, June 10, 1893.



## *Publications* No. 31, September 9, 1893.

*Publications* No. 32, November 25, 1893.

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| Thomas Porter | Lauriston, Ballarat, Australia. |
| Charles A. Post | Bayport, Long Island, N. Y. |
| Thomas Prather | President Union Savings Bank, Oakland, Cal. |
| Manuel G. Prieto | Tacubaya, Mexico. |
| Prof. H. S. Pritchett | Observatory of Washington University, St. Louis, Mo. |
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## LIST OF CORRESPONDING OBSERVATORIES AND INSTITUTIONS.

[Arranged Alphabetically by Cities.]

Dudley Observatory, Albany, New York.
Observatory, Algiers, Africa.
Allegheny Observatory, Allegheny, Penn.
Lawrence Observatory, Amherst, Mass.
Detroit Observatory, Ann Arbor, Michigan
Observatory, Armagh, Ireland.
Library, University of California, Berkeley, Cal.
Redaction Berliner Jahrbuch, Berlin, Germany.
Royal Observatory, Berlin, Germany.
Gesellschaft Urania, Berlin, Germany.
Observatory, Berne, Switzerland.
University Observatory, Bonn, Germany.
Observatory, Bordeaux, France.
Royal Observatory, Uccle, Brussels, Belgium.
University Observatory, Cambridge, England.
Harvard College Observatory, Cambridge, Mass.
*Royal Observatory, Capetown, Africa.*
Astronomical Society, Chicago, Illinois.
University Observatory, Christiania, Norway.
University Observatory, Cincinnati (Mt. Lookout), Ohio.
Litchfield Observatory, Clinton, New York.
National Observatory, Cordoba, Argentine Republic.
Chamberlin Observatory, Denver, Colorado.
Astronomical Society of Michigan, Detroit, Michigan.
University Observatory, Dorpat, Russia.
Trinity College Observatory, Dublin, Ireland.
Royal Observatory, Edinburgh, Scotland.
Lick College, Fredericksburg, Lebanon Co., Pennsylvania.
Observatory, Geneva, Switzerland.
College Observatory, Georgetown, District of Columbia.
Morrison Observatory, Glasgow, Missouri.
University Observatory, Glasgow, Scotland.
Ducal Observatory, Gotha, Germany.
Royal Observatory, Greenwich, England.
Observatory, Hamburg, Germany.
Shattuck Observatory, Hanover, New Hampshire.
University Observatory, Helsingfors, Russia.
Ducal Observatory, Karlsruhe, Germany.
University Observatory, Kasan, Russia.
University Observatory, Kiel, Germany.
University Observatory, Kœnigsberg, Germany.
Royal Observatory, Kopenhagen, Denmark.
Observatory, La Plata, Argentine Republic.

University Observatory, Leyden, Holland.
Astronomische Gesellschaft, Leipzig, Germany.
University Observatory, Leipzig, Germany.
Royal Observatory, Lisbon, Portugal.
Astronomical Society, Liverpool, England.
British Astronomical Association, London, England.
British Museum, London, England.
Royal Astronomical Society, London, England.
The Nautical Almanac, London, England.
University Observatory, Lund, Sweden.
Observatory, Lyons, France.
Washburn Observatory, Madison, Wisconsin.
Observatory, Madras, India.
Royal Observatory, Madrid, Spain.
Observatory, Marseilles, France.
Observatory, Melbourne, Victoria.
Stanford University, Menlo Park, California.
Royal Observatory, Milan, Italy.
University Observatory, Moscow, Russia.
Lick Observatory, Mt. Hamilton, California.
Royal Observatory, Munich, Germany.
Royal Observatory, Naples, Italy.
Observatory, Neuchâtel, Switzerland.
University Observatory, New Haven, Connecticut.
Observatory, Nice, France.
Observatory of Carleton College, Northfield, Minnesota.
Chabot Observatory, Oakland, California.
Radcliffe Observatory, Oxford, England.
University Observatory, Oxford, England.
Royal Observatory, Palermo, Italy.
Bureau des Longitudes, Paris, France.
Astronomical Society of France, Paris, France.
National Observatory, Paris, France.
Astrophysikalisches Observatorium, Potsdam, Germany.
University Observatory, Prague, Austro-Hungary.
Halstead Observatory, Princeton, New Jersey.
Imperial Observatory, Pulkowa, Russia.
Observatory, Rio de Janeiro, Brazil.
Observatory of the Roman College, Rome, Italy.
Italian Spectroscopic Society, Rome, Italy.
California Academy of Sciences, San Francisco, Cal.
Mercantile Library, San Francisco, Cal.
Mechanics' Institute Library, San Francisco, Cal.
Technical Society of the Pacific Coast, 819 Market Street, San Francisco, Cal.
Observatory, Santiago, Chile.
University Observatory, Stockholm, Sweden.
University Observatory, Strassburg, Germany.
Observatory of Sydney, New South Wales.

National Observatory, Tacubaya, Mexico.
University Observatory, Tokio, Japan.
Observatory, Toulouse, France.
University Observatory, Upsala, Sweden.
McCormick Observatory, University of Virginia, Virginia.
Imperial Observatory, Vienna, Austria.
VON KUFFNER'sches Observatory, Ottakring, Vienna, Austria.
The American Ephemeris, Washington, District of Columbia.
Library of Congress, Washington, District of Columbia.
National Academy of Sciences, Washington, District of Columbia.
Naval Observatory, Washington, District of Columbia.
Smithsonian Institution, Washington, District of Columbia.
U. S. Coast and Geodetic Survey, Washington, District of Columbia.
Library U. S. Military Academy, West Point, New York.
Field Observatory, Williamstown, Mass.
Observatory, Zurich, Switzerland.

# BY-LAWS

OF THE

# ASTRONOMICAL SOCIETY OF THE PACIFIC.*

ARTICLE I.

This Society shall be styled the ASTRONOMICAL SOCIETY OF THE PACIFIC. Its object shall be to advance the Science of Astronomy, and to diffuse information concerning it.

ARTICLE II.

This Society shall consist of Active and Life members, to be elected by the Board of Directors.

1. Active members shall consist of persons who shall have been elected to membership and shall have paid their dues as hereinafter provided.

2. Life members shall consist of persons who shall have been elected to life membership and shall have paid $50 (fifty dollars) to the Treasurer of the Society.

3. A certain number of Observatories, Academies of Science, Astronomical Societies, Institutions of Learning, etc., not to exceed one hundred, shall be designated by the Board of Directors as Corresponding Institutions, and they shall receive the publications of this Society in exchange or otherwise.

ARTICLE III.

At each annual election there shall be elected a Board of eleven Directors, and a Committee on Publication, consisting of three members. The officers of this Society shall be a President, three Vice-Presidents, two Secretaries and a Treasurer. The Directors shall organize immediately after their election, and elect from their number the officers of the Society. They may also appoint a Librarian, and such other assistants as may be required. The Directors shall fill by appointment any vacancies which may occur after the annual election.

The Library of the Society shall be kept in San Francisco, and shall be open to the use of all the members.

ARTICLE IV.

The President, or, in his absence, one of the three Vice-Presidents, or, in the absence of both the President and the Vice-Presidents, any member whom the Society may appoint, shall preside at the meetings of

* For the convenience of new members, the By-Laws now in force are here printed.

the Society. It shall be the duty of the President to preserve order, to regulate the proceedings of the meetings, and to have a general supervision of the affairs of the Society. The President is *ex-officio* a member of all Committees of the Board of Directors.

### ARTICLE V.

The Secretaries shall keep, and have the custody of, the records; they shall have the custody of all other property of the Society, excepting the money thereof; they shall give timely notice of the time and place of meetings; they shall keep in books a neat and accurate record of all orders and proceedings of the Society, and properly index them; they shall conduct the correspondence of the Society; they shall preserve and index the originals of all communications addressed to the Society; and keep a copy of all their letters, properly indexed; and they shall prepare for publication an accurate summary of the transactions of the Society at each of its meetings.

### ARTICLE VI.

The Treasurer shall receive and deposit in such bank as may be designated by the Directors, to the credit of the Society, all donations and bequests of money and all other sums belonging to the Society. He shall keep an account of all money received and paid by him, and at the annual meetings shall render a particular statement of the same to the Society. Money shall be paid by him only on the written order of the Finance Committee of the Board of Directors. He shall give such bonds as may be required by the Board of Directors.

### ARTICLE VII.

Candidates for active or life membership may be proposed by any member of the Society to either of the Secretaries, in writing. A list of such candidates shall be certified to the Board of Directors by the Secretaries at each of their meetings, in writing. A majority (not less than three) of the Directors present at any such meeting shall be required for election.

### ARTICLE VIII.

Each active member shall pay an annual subscription of five dollars, due on the first of January of each year, in advance. Each active member shall, on his election, pay into the Treasury of this Society the sum of five dollars, which shall be in lieu of the annual subscription to the first of January following his election, and in lieu of an initiation fee. No one shall be deemed an active member, or receive a diploma, until he has signed the register of members, or accepted his election to membership in writing, and paid his dues for the current year. Any member may be released from annual dues by the payment of fifty dollars at one time, and placed on the roll of life members by the vote of the Board of Directors. Any failure on the part of a member to pay his dues within six months after the time the same shall have become payable, shall be considered equivalent to a resignation.

ARTICLE IX.

The annual meeting of this Society shall be held on the last Saturday in March, at eight o'clock P. M., at the rooms of the Society in San Francisco; and meetings shall be held for the ordinary transactions and purposes of the Society, as follows:

Meetings shall be held in the Library of the Lick Observatory, Mount Hamilton, at a suitable hour on the second Saturday of June and the first Saturday of September; and meetings shall be held in the rooms of the Society, in San Francisco, at eight o'clock P. M., on the last Saturdays of January, March and November.

A special meeting may be called by the President, or, in his absence or disability, by one of the Vice-Presidents, or, in the absence or disability of both the President and the Vice-Presidents, by the Secretary, on the written requisition of ten active or life members; and the object of such meeting shall be stated in the notice by which it is called.

The annual election shall be held on the day of the annual meeting, between the hours of 8:15 and 9 P. M.

No member shall be permitted to vote at any meeting of the Society who has not paid all his dues for past and current years. There shall be no voting by proxy.

ARTICLE X.

Fifteen active or life members shall be a quorum for the transaction of business.

ARTICLE XI.

No papers or manuscripts shall be published by the Society without the consent of the Directors. Any motion to print an address, or other paper read before the Society, or any other matter belonging to the Society, shall be referred to the Committee on Publication, who shall report to the Directors. The Committee on Publication may make suggestions to the Directors, from time to time, with reference to the publication of such papers as in their judgment should be published by the Society; and this Committee shall have the care, direction and supervision of the publication of all papers which the Directors may authorize to have published.

Members of the Society shall receive all the publications of the Society free of charge.

ARTICLE XII.

This Society may, by a vote of a majority of all its active and life members, become a branch of an American Astronomical Society, should one be formed.

ARTICLE XIII.

It shall be the duty of the Directors, in case any circumstances shall arise likely to endanger the harmony, welfare or good order of the Society, to call a special meeting of the Society; and if, at such meeting, after an examination of the charges, and hearing the accused, who shall have personal notice of such proceedings, it shall be proposed that the

offending member or members shall be expelled, a vote by ballot shall be taken, and if two-thirds of the members present vote in favor thereof, the offending member or members shall be expelled.

ARTICLE XIV.

The Directors shall meet half an hour before the stated time of each bi-monthly meeting, and at such other times as they may appoint. The President, or, in his absence, any one of the Vice-Presidents, may call special meetings of the Board of Directors at any time. Notice of the time and place of such meeting shall be given by the Secretaries, by depositing in the post-office at San Francisco a notice of the time and place, addressed to each Director personally, at his last known place of residence, with the postage thereon prepaid, six days before the time of meeting.

ARTICLE XV.

The By-Laws may be amended at any time by a consenting vote of nine members of the Board of Directors at any duly called meeting thereof.

ARTICLE XVI.

In order to increase the usefulness of the Society, any groups of its members residing in the same neighborhood (except in the City and County of San Francisco, State of California) are authorized to form local organizations which shall be known as "The —— Section of the Astronomical Society of the Pacific."

No Section shall be formed except by the consent of the Board of Directors of the parent Society.

The proceedings of such Sections may be printed in the Publications of the Astronomical Society of the Pacific, either in full or in abstract, and the parent Society shall not be in any way responsible for publications made elsewhere.

No person not a member of this Society in good standing shall be eligible to membership in a Section, nor shall membership in a Section interfere in any way with the status of the person as a member of this Society.

The special expenses of each Section shall be borne by the group of members composing it, and this Society shall not be liable for any debts incurred by any Section.

ON THE WAY TO THE MOUNT BLANC OBSERVATORY.—I.

PUBLICATIONS

OF THE

Astronomical Society of the Pacific.

VOL. V. SAN FRANCISCO, CALIFORNIA, JANUARY 28, 1893. No. 28.

# *MARS.**

By SIR ROBERT S. BALL, F. R. S.

"It can hardly be urged that the general interest which has been expressed in regard to the opposition of *Mars* this year is merely due to the exigencies of the dull season. The newspapers, crowded as they are with their staple political matters, can still make room for paragraphs, columns, and even for long articles on the phenomena of our neighboring globe. It is worth while to examine the circumstances which have led to the direction of so much attention to this particular heavenly body at this particular time.

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From one cause or another, it happens that *Mars* is the most world-like of all the other globes which come within the range of effective observation. It would, indeed, be very rash to assert that other bodies may not have a closer resemblance to our earth than *Mars* has, but of them we have either little knowledge, as in the case of *Venus*, or no knowledge at all. No doubt both *Jupiter* and *Saturn* can vie with *Mars* in the copiousness of detail with which they delight the astronomers who study them. These grand planets are deserving of every attention, but then the interest they excite is of a wholly different kind from that which makes a view of *Mars* so attractive. *Jupiter* offers us a meteorological study of the most astounding cloud-system in creation. *Saturn* gives an illustration of a marvelous dynamical system the like of which would never have been thought possible had it not

* Reprinted (with omissions) from *Goldthwaite's Geographical Magazine* for December, 1892.

actually presented itself to our notice. But the significance of *Mars* is essentially derived from those points of resemblance to the earth which are now engrossing attention. *Mars* is clearly a possible world, presenting both remarkable analogies and remarkable contrasts to our own world, and inducing us to put forth our utmost endeavors to utilize so exceptional an occasion as that presented in the close approach which it has now made. Let us see what we have learned about this globe.

In the first place, it should be noticed that *Mars* must be a small world in comparison with our own. The width of this globe is only 4200 miles, so that its volume is but the seventh part of that of the earth. The weight of *Mars* is even less than what might have been expected from his bulk. It would take nearly ten globes, each as heavy as *Mars*, to form a weight equal to that of the earth. This fundamental difference in dimensions between *Mars* and our globe is intimately connected with certain points of contrast which it offers to the earth. Of these the most important is that which concerns the atmosphere. When we consider the qualification of a globe as a possible abode for organic beings, it is natural to inquire first into the presence or the absence of an atmosphere. Seeing that our earth is enveloped by so copious a shell of air, it follows that the beings which dwell upon its surface must be specially adapted to the conditions which the atmosphere imposes. Most, if not all, animals utilize this circumstance by obtaining a proximate source of energy in the union of oxygen from the atmosphere with oxidizable materials within their bodies. In this respect the atmosphere is of such fundamental importance that it is difficult for us to imagine what that type of life must be which would be fitted for the inhabitants of an airless globe. In other respects, which are hardly less important, the conditions of life are also dependent on the fact that we live at the bottom of an ocean of air. It is the atmosphere which, to a large extent, mitigates the fierceness with which the sun's rays would beat down on the globe if it were devoid of such protection. Again, at night, the atmospheric covering serves to screen us from the cold that would otherwise be the consequence of unrestricted radiation from the earth to space. It is, therefore, obvious that the absence of a copious atmosphere, though perhaps not absolutely incompatible with life of some kind, must still necessitate types of life of a wholly different character from those with which we are familiar. In attempting, therefore, to form an

estimate of the probability of life on another world, it is of essential importance to consider whether it possesses an atmosphere.

We may here lay down a canon which appears to be pretty general among the celestial bodies which are accessible to our observations. It may be thus stated. The larger the body the more copious the atmosphere by which that body is surrounded. Of course this rule has to be understood with certain qualifications, and perhaps some exceptions to it might be suggested, but as a broad general fact it will hardly be questioned. Thus, to take at once the largest body of our system and one of the smallest—the sun and moon—they both provide striking exemplifications of the principle in question. It is well known that the sun is enveloped by an atmosphere alike remarkable for the prodigious extent that it occupies and for the copiousness of the gases and vapors that abound in it. On the other hand, the moon, which is by far the smallest of the bodies readily accessible to our observations, is, if not entirely devoid of gaseous investment, at all events only provided with the scantiest covering of this nature. But the chief interest that the principle we have laid down possesses, is found in the explanation which has been given of it. That explanation is both so recent and so remarkable that I am glad here to have the opportunity of setting it forth, as it has an important application to *Mars*. The view of the subject here given is due to Dr. G. JOHNSTONE STONEY, F. R. S., who recently communicated it to the Royal Dublin Society.

Modern research has demonstrated that what we call a gas is in truth a mighty host of molecules far too small to be perceptible by the most powerful microscope. Each of these molecules is animated by a rapid movement, which is only pursued for a short distance in one direction before a rencontre takes place with some other molecule, in consequence of which the directions and velocities of the individual molecules are continually changing. For each gas the molecules have, however, a certain average pace, which is appropriate to that gas for that temperature, and when two or more gases are blended, as in our atmosphere, then each molecule of the constituent gases continues to move with its own particular speed. Thus, in the case of the air, the molecules of oxygen, as well as the molecules of nitrogen, are each animated by their characteristic velocity, and the same may be said of the molecules of carbonic acid or of any other gas which in more or less abundance may happen to be diffused through our air. For

two of the chief gases the average velocities of the molecules are as follows: oxygen, a quarter of a mile per second; hydrogen, one mile per second; in each case the temperature is taken to be 64° C. below zero, being presumably that at the confines of the atmosphere. It will be noticed that there is a remarkable difference between the speeds of the two molecules here mentioned. That of hydrogen is by far the greatest of any gas.

We may now recall a fundamental fact in connection with any celestial body, large or small. It is well known that, with the most powerful pieces of artillery that can be forged, a projectile can be launched with a speed of about half a mile per second. If the cannon were pointed vertically upwards the projectile would soar to a great elevation, but its speed would gradually abate, and the summit of its journey would be duly reached, after which it would fall back again on the earth. Such would undoubtedly be the case if the experiment were made on a globe resembling our own in size and mass. But on a globe much smaller than the earth, not larger, for instance, than are some of the minor planets, it is certain that a projectile shot aloft from a great Armstrong gun would go up and up, and would never return. The lessening gravitation of the body would fail to recall it. Of course we are here reminded of JULES VERNE'S famous Columbiad. According to that philosopher, if a cannon were pointed vertically and the projectile were discharged with a speed of seven miles a second, it would soar aloft, and whether it went to the moon or not, it would at all events not return to the earth except by such a marvelous series of coincidences as those which he has described. But the story will, at all events, serve to illustrate the fact that for each particular globe there is a certain speed with which if a body leaves the globe it will not return.

It is a singular fact that hydrogen in its free state is absent from our atmosphere. Doubtless many explanations of a chemical nature might be offered, but the argument Dr. STONEY has brought forward is most interesting, inasmuch as it shows that the continued existence of hydrogen in our atmosphere would seem to be impossible. No doubt the average speed at which the molecules of this gas are hurrying about is only one mile a second, and therefore only a seventh of the critical velocity required to project a missile from the earth so as not to return. But the molecules are continually changing their velocity, and may sometimes attain a speed which is seven times as great as the average.

Suppose, therefore, that a certain quantity of hydrogen were diffused through our air, every now and then a molecule of hydrogen in its wandering would attain the upper limit of our atmosphere, and then it would occasionally happen that with its proper speed it would cross out into space beyond the region by which its movements would be interfered with by the collisions between other atmospheric molecules. If the attraction of the earth was sufficient to recall it, then, of course, it would duly fall back, and in the case of the more sluggishly moving atmospheric gases the velocity seems always small enough to permit the recall to be made. But it happens in the case of hydrogen that the velocity with which its molecules are occasionally animated rises beyond the speed which could be controlled by terrestrial gravity. The consequence is that every now and then a molecule of hydrogen would succeed in bolting away from the earth altogether, and escaping into open space. Thus it appears that every molecule of free hydrogen which happened to be present in an atmosphere like ours would have an unstable connection with the earth, for wherever in the vicissitudes of things it happened to reach the very uppermost strata it would be liable to escape altogether. In the course of uncounted ages it would thus come to pass that the particles of hydrogen would all effect their departure, and thus the fact that there is at present no free hydrogen in the air over our heads may be accounted for.

If the mass of the earth were very much larger than it is, then the velocities with which the molecules of hydrogen wend their way would never be sufficiently high to enable them to quit the earth altogether, and consequently we might in such a case expect to find our atmosphere largely charged with hydrogen. Considering the vast abundance of hydrogen in the universe, it seems highly probable that its absence from our air is simply due to the circumstances we have mentioned. In the case of a globe so mighty as the sun, the attraction which it exercises, even at the uppermost layers of its atmosphere, is so intense that the molecules of hydrogen never attain pace enough to enable them to escape. Their velocity would have to be much greater than it ever can be if they could dart away from the sun as they have done from the earth. It is not, therefore, surprising to find hydrogen in the solar atmosphere. In a similar manner we can explain the abundance with which the atmosphere of other massive suns like *Sirius* or *Vega* seem to be charged with hydrogen.

The attraction of these vast globes is sufficiently potent to retain even an atmosphere of this subtle element.

It is now easy to account for the absence of atmosphere from the moon. We may feel confident from the line of reasoning here followed that neither of the gases, oxygen or nitrogen, to say nothing of hydrogen, could possibly exist in the free state on a globe of the mass and dimensions of our satellite. The pace with which the molecules of oxygen and nitrogen speed on their way would be quite sufficient to render their abode unstable if it should ever have appeared that circumstances placed such gases on the moon. We need, therefore, feel no surprise at the absence of any atmosphere from the neighboring globe. The explanation is given by the law of dynamics. We are placed at too great a distance from the small planets or asteroids, as they are called, to be able to see whether or not they have any gaseous surroundings. But it is possible, from the ingenious argument of Dr. STONEY, to assure ourselves that such small bodies must be quite as devoid of air as the moon. There are, we know, globes in our system only a few miles in diameter, and so small in mass that a cricket ball there, receiving the velocity it would get from the bat of a GRACE, would go off into space, never to return. It is quite obvious that the molecules of any gases we know would be far too nimble in their movements to remain prisoners at the surface of little globes of this description, to which their only bond was the feeble attraction of gravitation. It is, therefore, in the highest degree improbable— we might, indeed, almost say impossible — for gaseous surroundings to be preserved by any globe where the mass is not considerably greater than that of the moon.

In applying these considerations to *Mars* we have first to note that its mass and size are intermediate between those of the earth and the moon. It is much more capable of retaining an atmosphere than the moon, though its capability in this respect falls short of that possessed by the earth. But in such a case it is essential to depend not on mere generalities, but on the actual numerical facts of the case. Without going too deeply into details, it is sufficient to observe that there must be for each globe a certain critical velocity represented by the least pace at which a missile projected from it will succeed in escaping altogether. In discussing this we may leave out of view the question of the resistance which the air opposes to the passage of the projectile.

This is, no doubt, of vital importance in cases where actual artillery practice is concerned, yet it is not material to our present inquiry. The problem which we are considering depends on the movements of the molecules of air at the summit of the atmosphere, and the question is simply whether after they have made an incursion into free space there is sufficient efficiency in the attraction of the globe to effect their recall.

At the surface of *Mars* the speed which would carry a body away from its surface altogether is about three miles per second. It seems certain that the velocity of the molecules of hydrogen is often far in excess of this, and consequently free hydrogen is impossible as a permanent ingredient of the *Martian* atmosphere. Oxygen, however, has a molecular velocity only about one-fourth of that of hydrogen, and it seems unlikely that the oxygen molecules can ever have sufficient velocity to permit their escape from an atmosphere surrounding *Mars*. There is nothing, therefore, to prevent this element from being now present.

But the case of the vapor of water is especially instructive and interesting. Its molecules have a speed which averages about one-third of that attained by the molecules of hydrogen. It would seem that the utmost pace that the molecules of water could attain (being perhaps seven times the average velocity) would be about $2\frac{1}{3}$ miles per second. Now, this would not be enough for escape from *Mars*, for we have seen that a speed of three miles per second would be required for this purpose. This argument suggests that the globe of *Mars* happens to approach very closely the dimensions and mass of the smallest world on which the continued existence of water was possible. It would, perhaps, be going rather too far to say that a world almost the size of *Mars* must therefore be the smallest on which life could possibly be supported, but it is plain that our argument tends to support such a proposition.

The discussion we have just given will prepare us to believe that a planet with the size and mass of *Mars* may be expected to be encompassed with an atmosphere. Our telescopic observations completely bear this out. It is perfectly certain that there is a certain shell of gaseous material investing *Mars*. This is shown in various ways. We note the gradual obscuration of objects on the planet as they approach the edge of the disk, where they are necessarily viewed through a greatly increased thickness of *Martian* atmosphere. We also observe the clearness

with which objects are exhibited at the centre of the disk of ***Mars***, and though this may be in some measure due to the absence of distortion from the effects of foreshortening, it undoubtedly arises to some extent from the fact that objects in this position are viewed through a comparatively small thickness of the atmosphere enveloping the planet. Clouds are also sometimes seen apparently floating in the upper region of *Mars*. This, of course, is possible only on the supposition that there must be an atmosphere which formed the vehicle by which clouds were borne along. It is, however, quite obvious that the extent of the *Martian* atmosphere must be quite insignificant when compared with that by which our earth is enveloped. It is a rare circumstance for any of the main topographical features, such as the outlines of its so-called continents or the coasts of its so-called seas, to be obscured by clouds to an extent which is appreciable except by very refined observations. Quite otherwise would be the appearance which our globe would present to any observer who would view it say from *Mars*, or from some other external world at the same distance. The greater part of our globe would seem swathed with vast clouds, through which only occasional peeps could be had at the actual configuration of its surface. I dare say a Martian astronomer who had an observatory with sufficiently good optical appliances, and who possessed sufficient patience, might, in the course of time, by availing himself of every opportunity, gradually limn out a chart of the earth which would in some degree represent that with which we are familiar in our atlases. It would, however, be a very tedious matter, owing to the interruptions to the survey, caused by the obscurities in our atmosphere. The distant astronomer would never be able to comprehend the whole of our earth's features in a bird's-eye glance as we are able to do with those features on that hemisphere of *Mars* which happens to be turned toward us on a clear night.

As to what the composition of the atmosphere on *Mars* may be we can say but little. In so far as the sustenance of life is concerned, the main question of course turns on the presence or the absence of oxygen. It may be pertinent to this inquiry to remark here that a globe surrounded by air may at one epoch of its career have free oxygen as an ingredient in its atmosphere, while at other epochs free oxygen may be absent. This may arise from another cause besides the possible loss of the gas by diffusion into space from small globes in the manner already ex-

plained. Indeed, it seems quite probable that the oxygen in our own air is not destined forever to remain there. It passes through various vicissitudes by being absorbed by animals and then restored again in a free state under the influence of vegetation. But there is an appetite for oxygen among the inorganic materials of our globe which seems capable of using up all the oxygen on the globe and still remain unsatiated. We have excellent grounds for believing that there is in the interior of the earth a quantity of metallic iron quite sufficient to unite with all the free oxygen of the air so as to form iron oxide. In view of the eagerness with which oxygen and iron unite, and the permanence of the compound which they form, it is impossible for us to regard the presence of oxygen in the air as representing a stable condition of things. It follows that, even though there may be no free oxygen in the atmosphere of *Mars*, it is by no means certain that this element has always been absent. It is, however, not at all beyond the reach of scientific resources to determine what the actual composition and extent of the atmosphere of *Mars* may be, though it can hardly be said that as yet we are in full possession of the truth.

An almost equally important question is as to the telescopic evidence of the presence of water on *Mars*. Here, again, we have to be reminded of the fact that even at present, when the planet is relatively so near us, it is still actually a very long way off. It would be impossible for us to say with certainty that an extent which by its color and general appearance looked like an ocean of water was really water, or was even a fluid at all. It is so easy to exaggerate the capabilities of our great telescope that it may be well to recount what is the very utmost that could be expected from even our greatest instrument when applied to the study of *Mars*. Let us consider, for example, the capabilities of the LICK telescope in aiding such an inquiry as that before us. This instrument, both from its position and its optical excellence, offers a better view of *Mars* at the present time than can be obtained elsewhere. But the utmost that this telescope could perform in the way of rendering remote objects visible is to reduce the apparent distance of the object to about one-thousandth part of its actual amount. Some, indeed, might consider that even the LICK instrument would not be capable of giving so great an accession to our powers as this statement expresses. However, I am willing to leave the figure at this amount, only remembering

that if I estimated the powers of the telescope less highly than these facts convey, the arguments on which I am entering would be correspondingly strengthened.

As we have already said, *Mars* is at present at a distance of 35,000,000 miles, and if we look at it through a telescope of such a power as we have described, the apparent distance is reduced to one-thousandth part. In other words, all that the best telescope can possibly do is to exhibit the planet to us as it would be seen by the unaided eye if it were brought into a distance of 35,000 miles. This will demonstrate that even our greatest telescopes cannot be expected to enable us to answer the questions that are so often asked about our neighboring globe. What could we learn of Europe if we had only a bird's-eye view of it from a height of 35,000 miles, that is to say, from a height which was a dozen times as far as from the shores of Europe to America? The broad outlines of the coast might, of course, be seen by the contrast of the color of a continent and the color of the ocean. Possibly a great mountain mass like the Alps would be sufficiently noticeable to permit some conjecture as to its character to be formed. But it is obvious that it would be hopeless to expect to see details. The smallest object that would be discernable on *Mars* must be as large as London. It would not be possible to see a point so small as would either Liverpool or Manchester be if they were on that planet. There is, no doubt, a remarkable contrast between the dark colors of certain parts of *Mars* and the ruddy colors of other parts. It would, however, be going rather far to assert that the former must be oceans of water and the latter continents of land. This may indeed be the case, and most astronomers, I believe, think that it is the case, but it certainly has not yet been proved to be so.

Undoubtedly the most striking piece of evidence that can be adduced in favor of the supposition that there is water on *Mars* is derived from the "snowy" poles on the planet. The appearance of the poles of *Mars* with their white caps is one of the most curious features of the solar system. The resemblance to the structure of our own polar regions is extremely instructive. It is evident that there must be some white material which from time to time gathers in mighty volume round the north and south poles of the planet.

It is also to be noticed that this accumulation is not permanent. The amount of it waxes and wanes in correspondence with

the variations of the seasons on *Mars*. It increases during *Mars's* winter, and it declines again during *Mars's* summer. In this respect the white regions, whatever they may be composed of, present a noteworthy contrast to the majority of the other features on the planet. The latter offer no periodic changes to our notice; they are evidently comparatively permanent marks, not to any appreciable extent subject to seasonal variations. When we reflect that this white material is something which grows and then disappears according to a regular period, it is impossible to resist the supposition that it must be snow, or possibly the congealed form of some liquid other than water, which during *Mars's* summer is restored to a fluid state. There can hardly be a doubt that if we were ever able to take a bird's-eye view of our own earth its poles would exhibit white masses like those which are exhibited by *Mars*, and the periodic fluctuations at different seasons would produce changes just like those which are actually seen on *Mars*. It seems only reasonable to infer that we have in *Mars* a repetition of the terrestrial phenomenon of arctic regions on a somewhat reduced scale.

Among the features presented by *Mars* there are others in addition to the polar caps, which seem to suggest the existence of water. It was in September, 1877, when *Mars* was placed in the same advantageous position for observation that it occupies at present, that a remarkable discovery was made by Professor SCHIAPARELLI, the director of the Milan observatory. In the clear atmosphere and the convenient latitude of the locality of his observatory, he was so fortunate as to observe marks not readily discernible under the less advantageous conditions in which our observatories are placed. Up to his time it was no doubt well known that the surface of *Mars* could be mapped out into districts marked with more or less distinctness, so much so that charts of the planet had been carefully drawn and names had been assigned to the various regions which could be indicated with sufficient certainty. But at the memorable opposition to which we have referred, the distinguished Italian astronomer discovered that the tracts generally described as "continents" on *Mars* were traversed by long, dark "canals," as he called them. They must have been each at least sixty miles wide, and in some cases they were thousands of miles in length. Notwithstanding the dimensions to which these figures correspond, the detection of the *Martian* canals indicates one of the utmost refinements of astro-

nomical observation. The fact that they are so difficult to see may be taken as an illustration of what I have already said as to the hopelessness of discerning any object on this planet unless it be of colossal dimensions.

It is impossible to doubt that considerable changes must be in progress on the surface of *Mars*. It is true that, viewed from the distance at which we are placed, the extent of the changes, though intrinsically vast, seem relatively insignificant. There is, however, too much testimony as to the changes to allow of hesitation.

Speculations have naturally been made as to the explanation of these wonderful canals. It has been suggested that they may indeed be rivers; but it hardly seems likely that the drainage o continents on so small a globe as *Mars* would require an elaborate system of rivers each sixty miles wide and thousands of miles in length. There is, however, a more fatal objection to the river theory, in the fact that the marks we are trying to interpret sometimes cross a *Martian* continent from ocean to ocean, while on other occasions they seem to intersect each other. Such phenomena are, of course, well-nigh impossible if these so-called canals were in any respect analogous to the rivers which we know on our own globe. It can, however, hardly be doubted that if we assume the dark regions to be oceans, the canals do really represent some extension of the waters of these oceans into the continental masses. Other facts which are known about the planet suggest that what seem to be vast inundations of its continents must occasionally take place. Nor is it surprising that such vicissitudes should occur on a globe circumstanced like *Mars*. Here, again, it is well to remember the small size of the planet, from which we may infer that it has progressed through its physical evolution at a rate more rapid than would be possible with a larger globe, like the earth. The sea is constantly wearing down the land, but by upheavals arising from the intensely heated condition of the interior of our globe, the land is still able to maintain itself above the water. It can, however, hardly be doubted that if our earth had so far cooled that the upheavals had either ceased or were greatly reduced, the water would greatly encroach on the land. On a small globe like *Mars* the cooling of the interior has so far advanced that, in all probability, the internal heat is no longer an effective agent for indirectly resisting the advance of the water, and, consequently, the observed submergence is quite to be expected.

That there may be types of life of some kind or other on *Mars* is, I should think, very likely. Two of the elements, carbon and hydrogen, which are most intimately associated with the phenomena of life here, appear to be among the most widely distributed elements throughout the universe, and their presence on *Mars* is in the highest degree probable. But what form the progress of evolution may have taken on such a globe as *Mars* it seems totally impossible to conjecture. It has been sometimes thought that the ruddy color of the planet may be due to vegetation of some peculiar hue, and there is certainly no impossibility in the conception that vast forests of some such trees as copper-beeches might impart to continental masses hues not unlike those which come from *Mars*. Speculations have also been made as to the possibility of there being intelligent inhabitants on this planet, and I do not see how any one can deny the possibility, at all events, of such a notion. I would suggest, however, that as our earth has only been tenanted by intelligent beings for an extremely brief part of its entire history, say, for example, for about one-thousandth part of the entire number of years during which our globe has had an independent existence, so we may fairly conjecture that the occupancy of any other world by intelligent beings might be only a very minute fraction in the span of the planet's history. It would, therefore, be highly improbable, to say the least of it, that in two worlds so profoundly different in many respects as are this earth and *Mars*, the periods of occupancy by intelligent beings should happen to be contemporaneous. I should therefore judge that, though there may once have been, or though there may yet be, intelligent life on *Mars*, the laws of probability would seem against the supposition that there is such life there at this moment.

We have also heard surmises as to the possibility of the communication of inter-planetary signals between the earth and *Mars*, but the suggestion is a preposterous one. Seeing that a canal sixty miles wide and a thousand miles long is an object only to be discerned on exceptional occasions, and under most favorable circumstances, what possibility would there be that, even if there were inhabitants on *Mars* who desired to signal to this earth, they could ever succeed in doing so? We are accustomed to see ships signaling by flags, but what would have to be the size of the flags by which the earth could signal to *Mars*, or *Mars* signal to the earth? To be effective for such purpose each of the flags

should be at least as big as Ireland. It is true, no doubt, that small planets would be fitted for the residence of large beings, and large planets would be proper for small beings. The Lilliputians might be sought for on a globe like *Jupiter*, and the Brobdingnagians on a globe like *Mars*, and not *vice versâ*, as might be hastily supposed. But no Brobdingnagian's arms would be mighty enough to wave the flag on *Mars* which we should be able to see here. No building that we could raise, even were it a hundred times more massive than the Great Pyramid, would be discernible by the *Martian* astronomer, even had he the keenest eyes and the most potent telescopes of which our experience has given us any conception.

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## THE SUN'S MOTION IN SPACE.—III.*

By W. H. S. Monck.

Some time ago I communicated to this Society a simple mode of estimating the sun's motion in space, which I believed to be sufficiently accurate until we possess more reliable data than at present. I lately applied this method to Professor PORTER'S Catalogue of 301 stars, with proper motion of half a second or upwards, which appeared in *The Astronomical Journal* for June 13, 1892. I found that on seeking to divide the stars in respect of R. A. into two equal parts, one of which should contain the maximum amount of increasing and the other of diminishing Right Ascensions, the best divisions were from $7^h$ to $19^h$ and from $19^h$ to $7^h$, thus fixing the Right Ascension of the sun's goal at 285° (for the epoch 1900). The results were as follows:

| | Stars with motions in Increasing R. A. | Stars with motions in Diminishing R. A. | Stars with No motion in R. A. |
|---|---|---|---|
| $7^h$ to $19^h$ | 37 | 103 | 3 |
| $19^h$ to $7^h$ | 118 | 39 | 1 |

Dividing the stars with no motion in R. A. equally between + and —, and assuming that if the sun were motionless the proper motions in increasing and diminishing R. A. would be equal for both divisions, the result for $19^h$ to $7^h$ makes the sun's motion in R. A. exactly equal to the average motion of the stars, having

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* See *Publications A. S. P.*, Vol. IV., page 70.

converted exactly one-half of the really diminishing motions into increasing motions. But for the division $7^h$ to $19^h$ the effect of the sun's motion is only 92 per cent. of the average motion of the stars. We may adopt 96 per cent. as the mean of the two.

In respect of N. P. D., 210 stars gave a receding motion, 84 an approaching motion, and 7 were motionless. Adopting the same course here, the effect of the sun's motion in N. P. D. is only 72 per cent. of the average motion of the stars. Assuming that the average motion of the 301 stars is the same in Declination as in Right Ascension (or, rather, in parallel), we get for declination of the sun's goal, tan $\delta = \frac{72}{96} = \frac{3}{4}$: whence $\delta = 37^\circ$ nearly.

Professor PORTER does not deduce the sun's motion from these 301 stars, the divisions which he used being as follows: (1) 70 stars with motion of $1''.20$ annually; (2) 142 stars with motion of $0''.60$ to $1''.20$; (3) 533 stars with motion of $0''.30$ to $0''.60$; and (4) 576 stars with motion of $0''.15$ to $0''.30$. Of the 301 stars in question, 212 are included in the first two of these divisions and 89 in the third. The positions of the sun's goal obtained from his first three divisions are respectively $277^\circ.0$, $+34^\circ.9$, $285^\circ.2$, $+34^\circ.0$, and $280^\circ.7$, $+40^\circ.1$, all which, it will be seen, agree very fairly with my rough computation of $285^\circ$, $+37^\circ$. The sun's velocity in space could be estimated from these data if we knew the average velocity of the stars. VOGEL estimates the average velocity of the stars in the line of sight at 10.4 miles per second. Stars specially selected for their large proper motions may be expected to average more than this in R. A. and Decl. An average velocity of 12.5 miles per second in R. A. and Decl. for these stars would give a total velocity of about 15 miles per second for the sun.

Further consideration, however, qualifies these results. It seems now the general opinion of astronomers that the Milky Way consists of a cluster or system of stars chiefly of the *Sirian* type, while the solar stars, whose distribution over the sky is pretty uniform, chiefly belong to a different system. If this be so, we may expect a different goal when we employ *Sirian* and solar stars respectively. But stars with large proper motion, such as those used by Professor PORTER, are chiefly solar. In this Catalogue of 301 stars I succeeded in identifying 107 stars in the *Draper Catalogue*, of which only 9 had spectra of the *Sirian* type, while there were 97 solars. The goal thus determined can

differ very little from one determined by using solar stars only. And the same remark is partially applicable to the whole of the *Cincinnati Catalogue* used by Professor PORTER, and containing 1340 stars. In this Catalogue I only succeeded in identifying the spectra of 87 *Sirian* stars against 385 solars. When we employ stars with large proper motion to determine the sun's goal, it is plain that we are giving undue weight to solar stars and assigning too little weight to the Galaxy, if it really forms a separate system.

When we employ stars with small proper motion, on the other hand, our results are largely affected by errors, whether systematic or casual. That casual errors may effect the result can be thus shown: Suppose that the chance of changing a + into a — is, in the case of any given star, equal to that of changing a — into +, it is clear that if the plusses are in reality three times as numerous as the minuses, three times as many of them will be transferred to the minus side as there will be minuses transferred to the plus side. Casual errors will thus tend to equalize the number of stars on both sides, and thus to mask the effect of the sun's motion. But it seems to be conceded that errors occur more frequently in Right Ascension than in Declination. Hence, if we use stars with small proper motion, the equalizing process will be carried farther in Right Ascension than in Declination. The effect of the sun's motion in Declination will appear more clearly because it is less masked, and the result will be that a more northerly position will be obtained for the sun's goal.

The *Cincinnati Catalogue* confirms this conclusion in an unexpected way. Large proper motion is, of course, more likely to be attained when the effect of the sun's motion is additive than when it is subtractive. The motion of the sun towards the north pole makes the stars seem to move away from it, and a star which is really moving away from it is more likely to exhibit large proper motion in N. P. D. than one which is approaching. Now, on account of the uncertainties affecting motion in R. A., Professor PORTER adopted a higher limit for motion in R. A. than for motion in N. P. D. in his Catalogue—the one being practically $0''.225$ and the other $0''.150$. The result is that the *Cincinnati Catalogue*, taken as a whole, makes the effect of the sun's motion in N. P. D. greater than any other Catalogue that I have examined. Here are the results in R. A. and N. P. D. respectively ($7^h$ and $19^h$ seem again the best divisions in R. A.):

| | RIGHT ASCENSION. | | |
|---|---|---|---|
| | Increasing R. A. | Diminishing R. A. | No motion. |
| $7^h$ to $19^h$ | 179 | 437 | 34 |
| $19^h$ to $7^h$ | 439 | 207 | 44 |

North Polar Distance — receding 1002, approaching 302, no motion 36.

Treating this by my method, the position of the goal comes out at about 285°, + 55°; but I have little doubt that this high northerly Declination is merely owing to the fact that the Catalogue contains an undue preponderance of stars with large proper motion in N. P. D. This preponderance chiefly occurs in the fourth of Professor PORTER's divisions, for which his goal is 281°.9, + 53°.7. If he would extend his Catalogue so as to make the inferior limit in R. A. $0^s.01 \cdot \cos \delta$ instead of $0^s.015 \cdot \cos \delta$, I suspect the position of his goal for this division would be found to have moved several degrees to the south. We must be impartial as regards motion in R. A. and in Declination if we mean to arrive at satisfactory results. The greater liability of the former to errors may to a certain extent mask the effect of the sun's motion, but the masking is much greater when we omit stars with considerable motion in R. A. altogether. In fact, the R. A. as well as the Declination of every star in the Catalogue, is used in the computation. The majority of the stars introduced on account of their large motions in R. A. have comparatively small declinations, and *vice versâ*. The more stress, therefore, we lay upon large proper motions in Declination, the greater will be the proportion of small motions in R. A., with which we shall have to deal; and it is these small motions which are specially liable to error and to consequent masking of the sun's effect. It would, in fact, be better to adopt a lower limit in Right Ascension than in Declination in framing such a Catalogue, because the movements in R. A. with which we were dealing would, in that case, average more than the motions in Declination, and the effect of errors in the two cases would thus be more nearly equalized.

A determination of the sun's goal, using *Sirian* stars only for the purpose, would be worth making. A rough estimate from the stars in the *Cincinnati Catalogue* which I succeeded in identifying as *Sirian* makes the Northern Declination very small. But there is a strange peculiarity as regards the proper motion of these stars in N. P. D. In the first 12 hours of R. A. the excess of stars receding from the north pole is very great, but in the last

12 hours the majority of the *Sirian* stars are actually approaching the pole. Assuming the *Sirian* stars to be Galactic, this effect is exactly what would be produced by a revolution of the great Galactic ring, whose greatest northern and southern extensions are not far from $0^h$ and $12^h$ in Right Ascension.* The Galactic stars are thus moving to the N. in Aquila and to the S. in Taurus. The number of stars used (especially considering the manner in which the Catalogue has been compiled) is not sufficient to warrant a positive conclusion, but this seems to me to be the direction in which the evidence points. Of course, if such a revolution exists, the Galactic stars are not moving indifferently in all directions, and the motion of the Galaxy will have to be ascertained and allowed for in ascertaining the sun's goal with respect to it.

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## PHYSICAL OBSERVATIONS OF *JUPITER'S* SATELLITES IN TRANSIT.

By John Tebbutt, F. R. A. S.

The following notes on the physical appearances of *Jupiter's* satellites during transit have been condensed from the records in my observatory journal, and may prove interesting in connection with the communications already appearing from me in Vol. III of the *Publications of the Astronomical Society of the Pacific*, No. 16, page 221, and No. 19, page 353. The times given are local sidereal:

*Transit of Satellite II, September 12, 1891.*—The internal contact at ingress occurred at $18^h\ 33^m\ 21^s$. The satellite continued visible as a bright spot till $18^h\ 46^m$. It had ceased to be visible at $18^h\ 48^m\ 45^s$. Although the planet's disc was at intervals carefully examined, no further trace of the satellite could be seen till near the time of egress, when it again became visible as a bright spot. The observations were made with powers of 120 and 180 on the 4½-inch equatorial.

*Transit of Satellite III, October 2, 1891.*—The early part of this transit occurred during sunlight. At $19^h\ 6^m\ 13^s$ the satellite

* Taking the poles of the Galaxy as $0^h\ 50^m$ and $12^h\ 50^m$, I find 22 *Sirian* stars between $12^h\ 50^m$ and $0^h\ 50^m$ with approaching motion against 16 receding. The sun's goal deduced from the motions of these 38 stars would probably have a Southern Declination.

was seen in strong twilight as a dark spot on the western limb, but it was not near so conspicuous as its shadow on the opposite limb. It was, however, darker than the contiguous belt. At $19^h\ 17^m\ 43^s$ it was seen with great difficulty, and only suspected at $19^h\ 19^m\ 13^s$. It was then quite invisible till $19^h\ 22^m\ 58^s$, when it was suspected as a bright spot. I was certain of this phase at $19^h\ 26^m\ 3^s$. The internal contact at egress took place at $19^h\ 27^m\ 13^s$, but the satellite was unusually faint, and also appeared oval with its major axis parallel to the limb of its primary. The 8-inch equatorial was employed with a power of 230.

*Transit of Satellite I, October 19, 1891.*—The internal contact at ingress was observed at $21^h\ 37^m\ 31^s$. The satellite was still visible as a bright spot, but much fainter, at $21^h\ 42^m\ 26^s$. The definition then became very bad for a short interval. At $21^h\ 46^m\ 56^s$ the definition had improved, but the satellite was invisible, and, although the definition continued good till the time of mid-transit, it was not afterward seen. The transit was watched with a power of 170 on the 8-inch telescope.

*Transit of Satellite III, October 30, 1892.*—The internal contact at ingress was observed at $1^h\ 2^m\ 14^s$. The satellite continued visible as a bright spot till $1^h\ 27^m\ 54^s$. It was afterward occasionally glimpsed as a faint but light spot till $1^h\ 33^m\ 54^s$, when it became quite invisible. Owing to clouds the transit could not be completely observed. At the time of mid-transit the satellite could not be seen either as a bright or a dark spot. The 8-inch telescope was employed with a power of 300.

*Transit of Satellite III, December 12, 1892.*—Owing to other avocations I could not attend completely to this transit. A few minutes after the time of mid-transit there was certainly no trace of the satellite on the disc, but the definition was bad. The telescope of 4½ inches aperture was employed with a power of 120.

THE OBSERVATORY, WINDSOR, N. S. WALES,
1892, December 24.

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## NOTE FROM THE RETIRING PRESIDENT.

It has been the custom for the retiring President of the A. S. P. to give an address at the annual meeting. As I shall be more than 5000 miles away at the time, the omission of the customary address this year needs no further explanation.

MT. HAMILTON, January 14, 1893. J. M. SCHAEBERLE.

## (TWELFTH) AWARD OF THE DONOHOE COMET-MEDAL.

The Comet-Medal of the Astronomical Society of the Pacific has been awarded to EDWIN HOLMES, Esq., of London, England, for his discovery of an unexpected comet on November 6, 1892.

The Committee on the Comet-Medal,

EDWARD S. HOLDEN,
J. M. SCHAEBERLE,
CHARLES BURCKHALTER.

January 6, 1893.

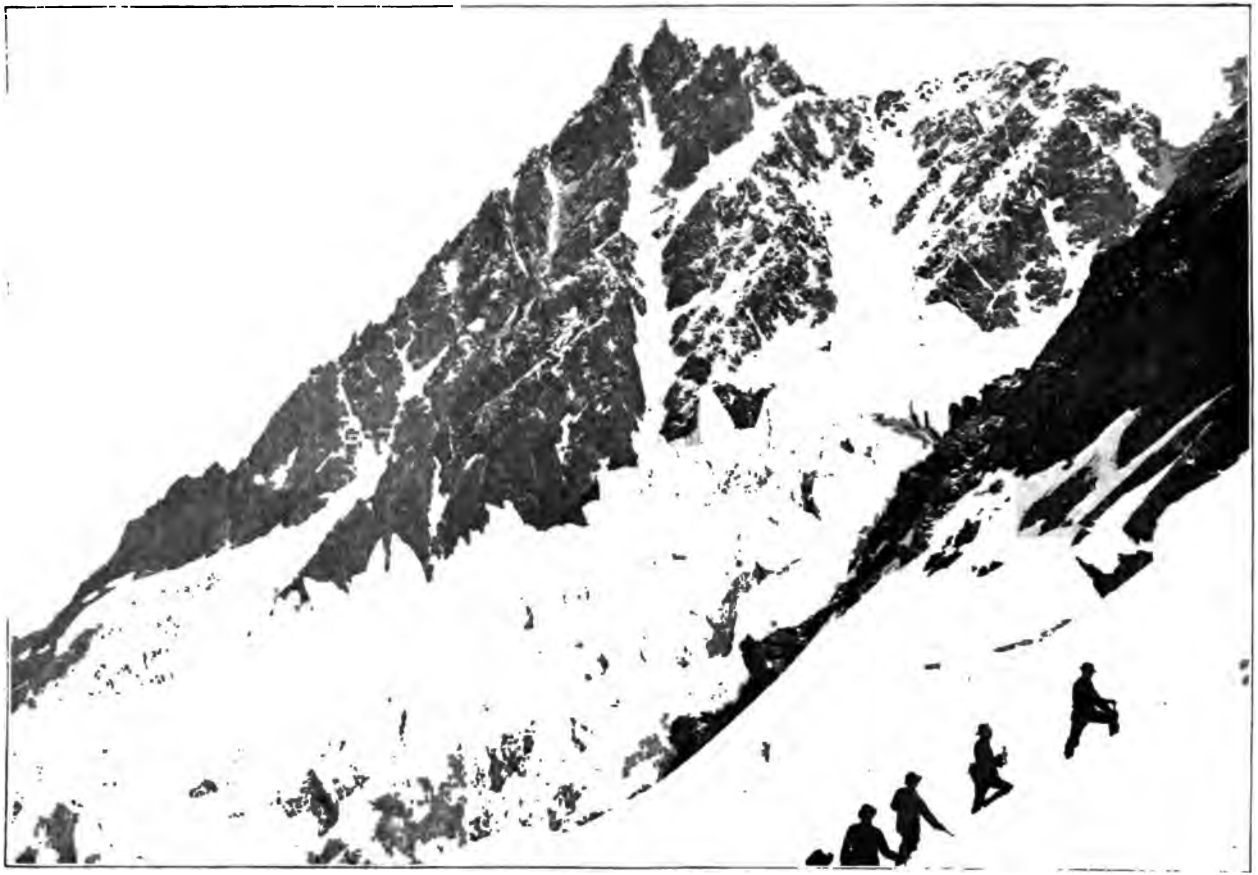
## (THIRTEENTH) AWARD OF THE DONOHOE COMET-MEDAL.

The Comet-Medal of the Astronomical Society of the Pacific has been awarded to Professor W. R. BROOKS, of Geneva, New York, for his discovery of an unexpected comet on November 19, 1892.

The Committee on the Comet-Medal,

EDWARD S. HOLDEN,
CHARLES BURCKHALTER,
W. J. HUSSEY.

January 19, 1893.



MOUNT BLANC OBSERVATORY.

# NOTICES FROM THE LICK OBSERVATORY.

Prepared by Members of the Staff.

## On Variations of Short Period in the Latitude* [by Lord Kelvin, President of the Royal Society].

[Note.—At the anniversary meeting of the Royal Society of London, November 29, 1892, Lord Kelvin presided, and delivered his annual address, from a report of which the two following paragraphs are taken:]

Last year he referred to the action of the International Geodetic Union in sending an astronomical expedition to Honolulu for the purpose of making a twelve months' series of observations on latitude, corresponding to twelve months' simultaneous observations in European observatories. The results were in splendid agreement with those of the observatories at Berlin, Prague, and Strasburg. They proved beyond all question that from May, 1891, to June, 1892, the latitude of each of the three European observatories was a maximum, and of Honolulu a minimum, in the beginning of October, 1891; that the latitude of the European observatories was a minimum, and of Honolulu a maximum, near the beginning of May, 1892; and that the variations during the year followed, somewhat approximately, a simple harmonic law for a period of 385 days, with a range of about ¼ sec. above and below the mean latitude in each case. He believed the true explanation of this apparent discrepance from dynamical theory was an elastic yielding of the earth as a whole. We had now, for the first time, what seemed to be a quite decisive demonstration of elastic yielding in the earth as a whole, under the influence of a deforming force, whether of centrifugal force round a varying axis, as in the present case, or of tide-generating influences of the sun and moon. When they considered how much water falls on Europe and Asia during a month or two of rainy

* See *Publications A. S. P.*, Vols. II, p. 135; III, p. 254; IV, p. 33.

season, and how many weeks or months must pass before it got to the sea, where it had been in the interval, and what had become of the air from which it fell, they need not wonder that the distance of the earth's axis of equilibrium of centrifugal force from the instantaneous axis of rotation should often vary by five to ten metres in the course of a few weeks or months.

## ON THE QUESTION OF THE INFLUENCE OF THE SUN UPON MAGNETIC STORMS ON THE EARTH [BY LORD KELVIN, PRESIDENT OF THE ROYAL SOCIETY].

Several communications to the Royal Society on the subject of simultaneous magnetic disturbances found by observations at magnetic observatories in different parts of the world justified him in saying a few words regarding terrestrial magnetic storms, and the hypothesis that they were due to magnetic waves emanating from the sun. Considering probabilities and possibilities as to the history of the earth from its beginning to the present time, he found it unimaginable, but that terrestrial magnetism was due to the greatness and the rotation of the earth. It seemed probable, also, that the sun, because of its great mass and its rotation in the same direction as the earth's rotation, was a magnet with polarities on the north and south sides of its equator, similar to the terrestrial northern and southern magnetic polarities. It was, therefore, a perfectly proper object for investigation to find whether there was or was not any disturbance of terrestrial magnetism, such as might be produced by a constant magnet in the sun's place with its magnetic axis coincident with the sun's axis of rotation. Even if (which did not seem very probable) we were to be led to believe that the magnetic force of the sun was directly perceptible on the earth, we might be quite certain that this steady force was vastly less in amount than the abruptly varying force which, from the time of Sir EDWARD SABINE'S discovery, forty years ago, of an apparent connection between sun spots and terrestrial magnetic storms, we had been almost led to attribute to disturbing action of some kind at the sun's surface. It had been a very tempting hypothesis that quantities of meteoric matter suddenly falling into the sun were the cause, or one of the causes, of those disturbances to which magnetic storms on the earth were due. We might, indeed, knowing that meteorites fall into the earth, assume without doubt that many more of them

fall, in the same time, into the sun. Astronomical reasons, however, led him long ago to conclude that their quantity annually, or per century, or per thousand years, was much too small to supply the energy given out by the sun in heat and light radiated through space, and led him to adopt unqualifiedly HELMHOLTZ'S theory that work done by gravitation on the shrinking mass was the true source of the sun's heat, as given out at present, and had been so for several hundred thousand years, or several million years. It seemed very improbable that meteors fall in at any time to the sun in sufficient quantity to produce dynamical disturbances at his surface at all comparable with the gigantic storms actually produced by hot fluid rushing up from below, and spreading out over the sun's surface. The magnetic storm of June 25, 1885, showed that in eight hours of a not very severe magnetic storm, as much work must have been done by the sun in sending magnetic waves out in all directions through space as he actually does in four months of his regular heat and light. This result, it seemed to him, was absolutely conclusive against the supposition that terrestrial magnetic storms were due to magnetic action of the sun, or to any kind of dynamical action taking place within the sun, or in connection with hurricanes in his atmosphere, or anywhere near the sun outside. It seemed as if they might also be forced to conclude that the supposed connection between magnetic storms and sun spots was unreal, and that the seeming agreement between the periods had been a mere coincidence. We were certainly far from having any reasonable explanation of any of the magnetic phenomena of the earth; whether of the fact the earth was a magnet; that its magnetism changed vastly, as it did from century to century; that it had somewhat regular and periodic annual, solar-diurnal, lunar-diurnal, and sidereal-diurnal variations, and (as marvelous as the secular variation) that it was subject to magnetic storms. The more marvelous, and for the present inexplicable, all these subjects were, the more exciting became the pursuit of investigations which must, sooner or later, reward those who persevered in the work. We had at present two good and sure connections between magnetic storms and other phenomena; the aurora above, and the earth currents below, were certainly in full working sympathy with magnetic storms.

## Relation Between the Proper Motion and Magnitudes of 1240 Stars.

Professor J. G. Porter has recently issued in the *Publications of the Cincinnati Observatory* a catalogue of *1240 Proper Motion Stars.* At the suggestion of Professor Holden, I have collected these results to determine the relation between the proper motion and the magnitude of a star. In order to make such a comparison, it is necessary to find the resultant of the proper motions in Right Ascension and Declination, or proper motion in a great circle as it is usually termed. A large number of the stars contained in Professor Porter's catalogue are also given in the catalogue of Dr. Stumpe (*A. N.*, Nos. 2999 and 3000) and in the latter the proper motion in a great circle is given. For all stars common to both catalogues the proper motions of Dr. Stumpe have been adopted and the proper motions in a great circle of the remainder have been determined by the following formulas:

$$\mu_0 \sin x = \Delta\, \alpha \cos \delta$$
$$\mu_0 \cos x = \Delta\, \delta$$

in which $\mu_0$ is the proper motion in a great circle. The proper motions of the two catalogues agree very closely in most instances, so if there is no systematic difference between them, and there seems not to be, then there can be no objection to combining the data of the two catalogues, as has in fact been done.

As a result of this work the following table was formed:

| Magnitude. | Proper Motion. | Number of Stars Observed. | Number of Stars North of Equator. |
|---|---|---|---|
| 1. to 3.5 | 0″.56 | 73 | 661 |
| 3.6 " 4.5 | 0.57 | 78 | 2,613 |
| 4.6 " 5.5 | 0.47 | 138 | 8,670 |
| 5.6 " 6.5 | 0.44 | 275 | 20,173 |
| 6.6 " 7.5 | 0.43 | 354 | 82,227 |
| 7.6 " 8.5 | 0.43 | 348 | 274,541 |
| 8.6 " 9.5 | [0.59] | 72 | 783,534 |

In all cases the magnitudes of Porter's catalogue have been used. The numbers in the last column were taken from Peirce's table of equable distribution, *Annals of H. C. O.*, vol. IX, page 26.

If the last horizontal line, in which the proportion of stars

observed is so small as not to warrant the drawing of any conclusions from the results, is left out of consideration, then the table shows a gradual decrease in the proper motion as the brightness decreases, which indicates that in general the brightest stars are our nearest neighbors. S. D. TOWNLEY.

## THREE-FOOT REFLECTING TELESCOPE FOR SALE.

An advertisement in *Astronomy and Astro-Physics* for February, 1892, announces that the three-foot reflecting telescope made for Dr. A. A. COMMON and afterwards sold by him to Mr. GLEDHILL is for sale, together with its Dome, etc. The price is not given. This is the instrument with which Mr. COMMON made his beautiful photographs of the Nebula of *Orion*, etc., for which he received the gold medal of the Royal Astronomical Society in 1884.

Such an instrument is exactly suited for photographs of nebulæ, comets and planets, and also for spectroscopic observations, and the capital results obtained by Dr. COMMON in the uncertain climate of England, give some idea of what might be expected if it were mounted in a situation like that at Mount Hamilton. I know of no better way to supplement the large refracting telescope of the LICK Observatory than by adding a large reflector to our equipment. The site for such an instrument is already selected and the work awaits it. The important item lacking is the money to provide for the cost of the instrument itself. E. S. H.

## METEOR-FALL IN OREGON, DECEMBER 16, 1892.

ALBANY, Oregon, December 17, 1892.

"About five o'clock yesterday morning FRED REIS saw a bright meteor approaching from the southeast. It was traveling very rapidly, and with a rushing sound fell into the street, followed by a wake of bright sparks. REIS hastened to the spot where it struck the earth and found a stone about fourteen inches in circumference. It was very hot, and charred the board upon which it was placed. The stone had the appearance of a volcanic production."—*New York Sun*, December 18.

[This stone is now in the possession of Messrs. WARD of Rochester, New York.]

## AWARD OF THE LALANDE PRIZE TO PROFESSOR BARNARD.

The LALANDE prize of the Paris Academy of Sciences was awarded to Professor BARNARD on December 19, 1892, for his work in Astronomy, especially for his discovery of the fifth satellite of *Jupiter*. E. S. H.

## OBSERVATIONS OF THE NOVEMBER METEORS IN THE HAWAIIAN ISLANDS (GOVERNMENT SURVEY, HONOLULU, H. I.), JANUARY 4, 1893.

Professor EDWARD S. HOLDEN, Director LICK Observatory—

Dear Sir: It may interest some of your astronomers to know that a shower of meteors was observed here on the 23d of November last. The meteors came at about an average of one per minute from 7 to 9 P. M. It was quite cloudy and hazy, but the divergent point was somewhere near *Aries*, or about overhead at that time, and the largest part of the meteors fell toward the southeast and southwest quadrants. They were small and attracted little attention, as the weather was very cloudy all that week.

The meteors of August, 1891, were few in number but very brilliant. Yours truly,

CURTIS J. LYONS,
Assistant in Charge of Office.

## "ASTRONOMICAL JOURNAL PRIZES.

"A gentleman, earnestly interested in the development and progress of astronomy in his native land, has authorized the editor of this journal to offer two prizes for resident citizens of the United States.

He expresses the hope that it may be possible to offer similar prizes in subsequent years, although only two are proposed at present, the requisite amount for these having been placed at the editor's disposal.

They will be known as *Astronomical Journal Prizes*, and will be given either in money or in the form of a suitable gold medal of the value of two hundred dollars, with the remainder, if any, in money, at the option of the recipient.

The awards will be made by a commission of three judges, to be selected from American astronomers, and their names to be announced in due time.

The prizes now offered are for researches tending to advance our knowledge of cometary orbits, and are these:

I.

For the observer making the best series of determinations of the positions of comets during the year ending on the thirty-first of March, 1894, a prize of two hundred dollars. The conditions to be considered in the award will be the accuracy of measurement and reduction, the number of the observations and their judicious distribution along the geocentric paths, and the promptitude of their publication. To equalize the claims of observers, due allowance will be made for the different optical powers of the telescopes used. Also, since there seems to have been a tendency to neglect such comets as are observable only in the morning, regard is to be had, in the award, to the especial usefulness of observations made at inconvenient hours.

II.

For the best discussion of the path of a periodic comet, with due regard to its perturbations, of the kind ordinarily known as the definitive determination of the orbit, a prize of four hundred dollars. The investigation must, however, have been made within the two years next preceding 1894, September 1; and the manuscript (which will be returned to the author) transmitted, not later than that date, to some one of the judges.

In these awards it will be left to the discretion of the judges to decide whether in case of uncertainty on account of nearly equal claims of two candidates, either of the prizes ought to be divided. Also, in case that either award should not, in their opinion, be fully justified, they will be authorized to withhold the same; in which event it will be offered again, under the same conditions, for the next ensuing year.

Should similar prizes be offered in the coming year, it is intended that one of them shall be for the best series of determinations of maxima and minima of variable stars during the years 1893 and 1894."

The commission of judges designated for the award of these prizes consists of Messrs. ASAPH HALL, SETH C. CHANDLER, LEWIS BOSS.

Two additional prizes are hereby offered, for the year 1895,

subject to the same conditions as were prescribed for those of the year 1894.

I.

For the observer making, by ARGELANDER'S method, the best series of determinations of maxima and minima of variable stars during the two years ending 1895, March 31, a prize of two hundred dollars. A principal basis for the award is to be the extent to which the determinations will contribute to our better knowledge of the periodic variables, by furnishing the largest number of maxima or minima of the largest number of stars, having especial regard to stars whose characteristics are at present not very well known.

II.

For the most thorough discussion of the theory of the rotation of the Earth, with reference to the recently discovered variations of latitude, a prize of four hundred dollars. The manuscript (which will be returned to the author) is to be transmitted to some one of the Judges, not later than 1895, March 31.

## WORKS ISSUED BY THE LICK OBSERVATORY.

It is intended to issue, at irregular intervals, two series of works, the first, in quarto, to be known as *Publications* of the LICK Observatory; the second, in octavo, to be known as *Contributions* from the LICK Observatory. Occasional pamphlets, such as No. 2 below, may not be included in either series. At the end of every book, a list of all the works issued will be given, for the convenience of librarians and others.

For the sake of uniformity, Nos. 3 and 4 below will be counted as *Contributions* Nos. 1 and 2.

1. *Publications* of the LICK Observatory of the University of California, prepared under the direction of the LICK Trustees by EDWARD S. HOLDEN, Volume I, 1887. Sacramento, 1887, 4to. [Containing a brief history of the Observatory, with descriptions of the buildings and instruments; observations of double stars by S. W. BURNHAM, 1879, of the transit of *Mercury*, 1881, by Messrs. FLOYD, HOLDEN and BURNHAM, of the transit of *Venus*, 1882, by D. P. TODD; meteorological observations by T. E. FRASER, 1880–85; and Reduction Tables for Mt. Hamilton, by G. C. COMSTOCK.]

2. Suggestions for Observing the Total Eclipse of the Sun on January 1, 1889, by EDWARD S. HOLDEN. Printed by authority

ON THE WAY TO THE MOUNT BLANC OBSERVATORY.—*III.*

(From *The Illustrated American.*)

of the Regents of the University of California. Sacramento, 1880, 8vo. [Out of print.]

3. *Contributions* from the LICK Observatory, No. 1. Reports on the Observations of the Total Eclipse of the Sun of January 1, 1889, published by the LICK Observatory. Printed by authority of the Regents of the University of California. Sacramento, 1889, 8vo. [Out of print.]

4. *Contributions* from the LICK Observatory, No. 2. Reports on the Observations of the Total Eclipse of the Sun, December 21-22, 1889, and of the Total Eclipse of the Moon, July 22, 1888, to which is added a Catalogue of the Library, published by the LICK Observatory. Printed by authority of the Regents of the University of California. Sacramento, 1891, 8vo. [Out of print.]

5. *Contributions* from the LICK Observatory, No. 3. Terrestrial Atmospheric Absorption of the Photographic Rays of Light, by J. M. SCHAEBERLE, Astronomer in the LICK Observatory. Printed by authority of the Regents of the University of California. Sacramento, 1893, 8vo.

6. *Publications* of the LICK Observatory of the University of California. Printed by authority of the Regents of the University. Volume II, 1893. Sacramento, 1893, 4to. [Containing double star observations made with the thirty-six-inch and twelve-inch refractors of the LICK Observatory from August, 1888, to June, 1892, by S. W. BURNHAM.]

## ENLARGEMENTS OF THE LICK OBSERVATORY NEGATIVES OF THE MOON, BY BARON ALBERT VON ROTHSCHILD.

Baron ROTHSCHILD has had the kindness to present to the LICK Observatory two splendid enlargements from (a copy of) a negative made at Mt. Hamilton, on July 14, 1891. The enlargements are 24 inches by 20 inches, on a scale of 79 English inches to the moon's diameter. The definition is good throughout. The grain of the (carbon) paper employed is not so manifest as the grain of the glass enlargements which we have made here on the same scale. The contrasts of light and shade of the original plate are perhaps better preserved on the whole in our glass reproductions than in the carbon copies. It will be noticed that the scale of Baron ROTHSCHILD'S enlargements is greater than that of SCHMIDT'S lunar map; and it is thus manifest that our original negatives can be enlarged on paper up to VI Paris feet in diameter

by purely photographic processes in an entirely satisfactory manner. The LICK Observatory has no facilities for making enlargements of this sort upon paper, and we have made no experiments in enlargements except upon glass plates. The highly successful experiments of Baron ROTHSCHILD are therefore all the more welcome. E. S. H.

### HELIOGRAVURE OF *MARE CRISIUM* AND VICINITY.

The frontispiece to Volume V of 1893 of the *Publications* is a heliogravure of *Mare Crisium* and vicinity, copied from a drawing made by Professor WEINEK from LICK Observatory negatives. The impressions printed in our volume have been presented to the Society by Mrs. PHEBE HEARST. The great advantage of the heliogravure process over others may be seen by comparing the print in No. 27, A. S. P., with the phototype engraving given on page 81 of Volume IV.

Professor WEINEK is now preparing a volume of such heliogravures, which will be published by the LICK Observatory by the aid of a gift from Mr. LAW of New York. A few of his drawings have already been published in the *Zeichnungen und Studien des Mondes*, Prague, 1893. E. S. H.

### THE PROPOSED OBSERVATORY ON MONT BLANC.

The three wood-cuts in the present number are here printed by permission of the editors of the *Illustrated American*, New York. They illustrate in a striking manner the difficulties to be overcome in placing an observatory upon the summit of this high mountain. These difficulties are described in some detail in these *Publications*, Vol. III, page 50, and Vol. IV, page 181.

The height of Mont Blanc is 15,700 feet. Pike's Peak in Colorado is 14,134 feet high and its summit is connected by *railway* with the neighboring town of Manitou. It would seem, therefore, to have certain practical advantages over the French station. E. S. H.

### FALL OF A METEORIC STONE IN INDIA IN A. D. 1621.

In the Memoirs of the Mogul Emperor JAHANGIR (ELLIOT'S History of India, Vol. VI, page 378) the following interesting chronicle appears:

"*Fall of a Meteoric Stone.*

"On the morning of the 30th *Farwardin* of the present year [XVI year of the reign which began 10th March, 1621], a very

loud and dreadful noise arose from the east * * In the midst of the noise a light fell on the earth from the sky * * The chief officer of the village rode immediately to the spot 'and saw the place with his own eyes.' The land for about ten or twelve yards in length and breadth was so burned that not a blade of grass was found there. The ground was yet warm. He ordered it to be dug and the deeper it was dug the warmer the ground was found to be. At last a piece of iron appeared which was as hot as if it had just been taken out of a furnace." It was sealed in a bag and sent to the Emperor and was found to weigh 160 *tolas*, which, I believe, is about 66 pounds. Two swords, a knife and a dagger were made from it, by mixing three parts of the meteoric iron with one part of common iron; and the blades were excellent—"equal to the best tempered swords." E. S. H.

## ANCIENT COMETS.

The following references have some value to a compiler of a Catalogue of Ancient Comets:—

"In 330 A. H. (941–2 A. D.) a comet made its appearance, the tail of which reached from the eastern to the western horizon. It remained in the heavens eighteen days * * *" ELLIOT'S History of India, Vol. II, page 505. [This is probably either No. 309 or 310 of CHAMBERS' Catalogue (II) of Comets; WILLIAMS' Chinese Comets, Nos. 54, 64.]

Thirteenth year of the reign of the Mogul Emperor JAHANGIR: "*Saturday*, 17th *Zi-l ka'da.* Several nights before this, a little before dawn, a luminous vapor, in the form of a column, had made its appearance, and every succeeding night it arose half an hour earlier than on the preceding night. When it had attained its full development, it looked like a spear (*or* like a porcupine), with the two ends thin, but thick about the middle. It was a little curved, like a reaping-sickle, with its back towards the south and its edge towards the north. On the date above mentioned it rose three hours before sunrise. The astronomers measured its size with their astrolabes and, on an average of different observations, it was found to extend 24 degrees. Its course was in the empyrean heaven, but it had a proper motion of its own, independent of that firmament, as it was retrograde—first appearing in the sign of the *Scorpion*, then in that of the *Scales*. Astrologers have written that it portends evil to the chiefs of Arabia. Allah only knows if this be true!

"Sixteen nights after its first appearance, a comet appeared in the same quarter, having a shining nucleus, with a tail in appearance about two or three yards long, but in the tail there was no light or splendor." [ELLIOT'S History of India, Vol. VI, pages 363 and 406. This is probably Comet 1618, II. See also MALCOLM'S Persia, Vol. I, page 359, foot-note. CHAMBERS' Catalogue (II) No. 500 *q. v.*]

A. H. 237 = A. D. 857. "A great fiery meteor appeared in Askalan, which was for a long time suspended between heaven and earth." [CHAMBERS' Catalogue (II) No. 276.]

A. H. 328 = A. D. 941. "Stars fell from the sky which appeared like birds of fire and which greatly terrified the people."

A. H. 442 = A. D. 1050. "A comet appeared." [See CHAMBERS' Catalogue (II) No. 343.]

A. H. 836 = A. D. 1433. "A comet appeared." [See CHAMBERS' Catalogue (II) No. 447.]

[The last four extracts are also from Sir HENRY ELLIOT'S History of India, Vol. VIII, pages 31-36.]

A. H. 396 = A. D. 1015–16. "A comet made its appearance for fifteen nights successively and was as large as the Moon." [CHAMBERS' Catalogue (II) No. 330; *ibid.*, Vol. IV, page 171, note.] E. S. H.

### APPOINTMENTS IN THE LICK OBSERVATORY.

Mr. R. H. TUCKER, now of the National Observatory of the Argentine Republic, formerly of the DUDLEY Observatory, has been appointed Astronomer in the LICK Observatory from July 1; and Mr. C. D. PERRINE has been appointed Secretary of the Observatory from March 1, 1893. E. S. H.

### DISCUSSION OF PROFESSOR BARNARD'S OBSERVATIONS OF THE FIFTH SATELLITE OF *JUPITER*.

Professor BARNARD has printed all his observations of the fifth satellite of *Jupiter* in the *Astronomical Journal*. Professor H. S. PRITCHETT of Washington University, St. Louis, has undertaken the discussion of these observations and the determination of the orbit, so far as this year's work is sufficient.

E. S. H.

## OBSERVATIONS OF *NOVA AURIGÆ* (February 9 to 14, 1893).

Number 26 of the *Publications* contains an extended history of the new star in *Auriga*, based upon observations made at Mt. Hamilton. The positions of the chief nebular line showed that the *Nova* was approaching the solar system with a variable velocity, which decreased from about 190 miles per second in September to about 85 in November (see page 247). My absence from the observatory prevented observations in December and January, but recent measures show that further variations have occurred. The wave lengths and velocities (in miles per second) obtained are:

| Date. | $\lambda$ | Velocity. |
|---|---|---|
| 1893, Feb. 9 | 5007.5 | +17 |
| 10 | 6.2 | −30 |
| 14 | 6.1 | −33 |

[The result for February 9 is to be rejected on account of the fact that the micrometer wire was subsequently found to have been crooked].

In all the observations the nebular line has been compared with the lead line at $\lambda$ 5005.63. In 1892 the nebular line was more refrangible than the lead line; it is now less refrangible than the lead line. W. W. C.

## LICK OBSERVATORY ECLIPSE EXPEDITION.

A letter from Professor SCHAEBERLE announces that he arrived at Panama on February 10, and complains that he will be obliged to wait six days for the steamer down the coast. As Panama is one of the few places where fresh pine-apples and northern ice can be had at the same time, he is to be congratulated, not pitied.

E. S. H.

## Minutes of a Special Meeting of the Board of Directors, held in San Francisco, December 29, 1892, at 4:30 P. M.

Mr. Camilo Martin presided. A quorum was present. The minutes of the last meeting were approved.

The following members were duly elected:

List of Members Elected December 29, 1892.

| | |
|---|---|
| Carl H. Abbott | 118 11th St., Oakland, Cal. |
| Augustin Aragón | Puerta falsa de la Merced No. 3, City of Mexico, Mexico. |
| Dr. Harriet Aucutt | 726 23d St., Ogden, Utah. |
| R. D. Baker | 356 E. 22d St., E. Oakland, Cal. |
| Dr. J. D. Brownlee | 752 S. 3d St., San José, Cal. |
| E. K. Chapman | 315 Montgomery St., S. F., Cal. |
| Miss Jeannette Dougherty | 410 Ellis St., S. F., Cal. |
| Prof. Melville Dozier | State Normal School, Los Angeles, Cal. |
| Hon. J. Diaz Duran | 204 Front St., S. F., Cal. |
| W. B. Featherstone | 2116 Bush St., S. F., Cal. |
| Allen F. Gillihan | 135 Pandora St., Victoria, B. C. |
| Prof. D. Grawe | Observatory, University of St. Petersburg, St. Petersburg, Russia. |
| Hermann Iwersen | Consul for Sweden and Norway, Nagasaki, Japan. |
| Charles H. Jackson | 628 Sutter St., S. F., Cal. |
| W. E. Keith | Riverside, Cal. |
| Prof. Andrew Cowper Lawson | Berkeley, Cal. |
| Charles Matson | Box 30, Edison, Skagit Co., Washington. |
| Peter McEwen | 819 Market St., S. F., Cal. |
| H. E. Parker | 57 Railroad Ave., E. E., Bridgeport, Conn. |
| Charles A. Post | Bayport, Long Island, N. Y. |
| Miss Grace Rand | Lombard, Illinois. |
| Dr. W. H. Rollins | 250 Marlboro St., Boston, Mass. |
| Prof. A. Shdanow | Observatory, University of St. Petersburg, St. Petersburg, Russia. |
| Samuel Sonnenfeld | 331 Kearney St., S. F., Cal. |
| Prof. W. H. von Streeruwitz | P. O. Box 465, Austin, Texas. |
| S. D. Townley | University of California, Berkeley, Cal. |
| J. Howard Wilson | 753 Carroll St., Brooklyn, N. Y. |

It being announced to the Board that Professor SCHAEBERLE, one of the members of the Comet-Medal Committee, is to be absent from the State on solar eclipse work during some months in 1893, it was

*Resolved*, That Professor W. J. HUSSEY be and he is hereby appointed a member of the Comet-Medal Committee, to act in Professor SCHAEBERLE's place during his absence.

On motion the following resolutions were adopted:

*Resolved*, That whenever in the judgment of the Treasurer there is a sufficient amount of money belonging to the Society on general deposit, he is hereby authorized to withdraw all over $200, and deposit the same with the SECURITY SAVINGS BANK, at interest, and to withdraw the same from the latter only when needed for the current expenses of the Society.

*Resolved*, That the President and Secretary of the Society be instructed to communicate with the Regents of the University of California and to request them to allow the Society the use of rooms in the Hopkins-Searles house in San Francisco.

*Resolved*, That if this privilege be granted, the President and the two Secretaries be authorized to make the necessary arrangements for transferring the property and collections of the Society to the new quarters.

*Resolved*, That the Directors approve the letter (dated December 29, 1892), of the President and Secretary to the Regents, and accept the conditions there stated.

It was the sense of the Board that all correspondence of the Society should be filed in the Society's archives in San Francisco; the Secretary was therefore instructed to request the Secretary at Mt. Hamilton to forward to the Secretary here all papers and correspondence belonging to the Society, and that the same be bound in volumes as soon as they accumulate sufficiently to form convenient sized books.

Adjourned.

## MINUTES OF THE MEETING OF THE BOARD OF DIRECTORS HELD AT THE CHABOT OBSERVATORY, JANUARY 28, 1893.

Vice-President MOLERA presided. A quorum was present. The minutes of the last meeting were approved.

Mr. ROBERT ISAAC FINNEMORE of Durban, South Africa, and Mr. E. J. MOLERA of San Francisco, were elected to life membership.

The following members were duly elected:

### LIST OF MEMBERS ELECTED JANUARY 28, 1893.

| | |
|---|---|
| Dr. JAMES X. ALLEN | 365 23d St., Ogden, Utah. |
| Mrs. JOHN H. DEVEREUX | 869 Euclid Ave., Cleveland, Ohio. |
| Hon. MANUEL FERNANDEZ LEAL | Calle de Cordovanes No. 3, City of Mexico, Mexico. |

| | |
|---|---|
| F. B. RANDALL, U. S. R. M. . . . . | U. S. Rev. Str. "Corwin," S. F., Cal. |
| FRED. H. SEARES . . . . . . . . . . . | Berkeley, Cal. |
| Mrs. ELLA M. SEXTON . . . . . . . . . | 113 Sullivan St., S. F., Cal. |
| CHARLES SLEEPER . . . . . . . . . . . | 211 Sansome St., S. F., Cal. |
| ALLAN STOCKTON . . . . . . . . . . . | Bethayres, Montgomery Co., Pa. |
| F. G. STOKES, B. A. . . . . . . . . . | Care Rev. H. C. Hawtrey, S' Mark's School Windsor, Berks, England. |
| Prof. J. W. STUMP . . . . . . . . . . . | 24 Montcalm St., Oswego, N. Y. |

The following papers were presented:

1. Notes on Transits of the Satellites of *Jupiter*, by JOHN TEBBUTT.

2. The Sun's Motion in Space, by W. H. S. MONCK.

Adjourned.

## MINUTES OF THE MEETING OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC, HELD AT THE CHABOT OBSERVATORY IN OAKLAND, JANUARY 28, 1893.

Vice-President MOLERA presided. The minutes of the last meeting were approved.

The list of new members elected at the Directors' meeting was read to the meeting.

It was voted that the thanks of the Society be returned to the officers of the School Department and to Mr. BURCKHALTER, for the use of the Chabot Observatory.

The minutes of a meeting of the Board of Directors, held on December 29, 1892, were read.

A number of presents were announced, and the thanks of the Society were voted to the givers.

A committee to nominate a list of eleven Directors and Committee on Publications, to be voted for at the annual meeting, was appointed, as follows: Messrs. F. H. McCONNELL (Chairman), J. COSTA, JOHN PARTRIDGE, C. A. MURDOCK and T. C. JOHNSTON.

A committee to audit the accounts of the Treasurer, and to report at the annual meeting, was appointed, as follows: Messrs. JOSEPH G. LAVERY (Chairman), CHAS. G. YALE and H. S. HERRICK.

The hall was darkened, and Mr. BURCKHALTER, assisted by Mr. SANDS, exhibited a large number of lantern slides; after which the spectrum was projected by means of an arc light, and the sodium and other lines shown, and absorptions of colors practically illustrated.

At the close of the meeting the Equatorial Telescope was placed at the disposal of the members.

## OFFICERS OF THE SOCIETY.

J. M. SCHAEBERLE (Lick Observatory), . . . . . . . . . . *President*
E. J. MOLERA (850 Van Ness Avenue, S. F.), . . . . . . . . } *Vice-Presidents*
FRANK SOULÉ (Students' Observatory, Berkeley), . . . . . . }
OTTO VON GELDERN (819 Market Street), . . . . . . . . }
W. W. CAMPBELL (Lick Observatory), . . . . . . . . . *Secretary*
F. R. ZIEL (410 California Street, S. F.), . . . . . . *Secretary and Treasurer*

*Board of Directors*—Messrs. ALVORD, CAMPBELL, HILL, HOLDEN, CAMILO MARTIN, MOLERA, PIERSON, SCHAEBERLE, SOULÉ, VON GELDERN, ZIEL.

*Finance Committee*—Messrs. PIERSON, MARTIN, ZIEL.

*Committee on Publication*—Messrs. HOLDEN, CAMPBELL, YALE.

*Library Committee*—Messrs. MOLERA, VON GELDERN, HILL.

*Committee on the Comet Medal*—Messrs. HOLDEN (*ex-officio*), SCHAEBERLE, BURCKHALTER.

## OFFICERS OF THE CHICAGO SECTION.

*Executive Committee*—Messrs. DOUGLASS (Chairman), EWELL, HALE (Secretary), PIKE, THWING.

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## NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book-keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend any or all of the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

FOREST FIRE NEAR MOUNT HAMILTON, AUGUST, [illegible]

PUBLICATIONS

OF THE

# Astronomical Society of the Pacific.

VOL. V. SAN FRANCISCO, CALIFORNIA, MARCH 25, 1893. NO. 29.

## ADDRESS OF THE FIRST VICE-PRESIDENT, AT THE FIFTH ANNUAL MEETING, MARCH 25, 1893.

BY E. J. MOLERA.

The President of this Society, being now more than 5,000 miles away, and constituting, alone, the expedition from the observatory at Mt. Hamilton, to observe the coming total eclipse of the Sun, cannot address you to-night.

A week ago I was in the City of Mexico, and had to travel nearly 3,000 miles from the Halls of Montezuma to this Temple of Science, for the pleasure of attending this meeting. I crave your kind indulgence, if, instead of the excellent addresses you have heard on similar occasions, you hear to-night the improvisation of an amateur astronomer.

The prosperity which our Society has enjoyed since its beginning has continued during the last year, and is still on the increase. The numbers 40, 192, 360 and 432 represent the membership at the formation of the Society, and at the beginning of the years 1890, 1891, 1892; this year began with 493 names on our roll, of which 438 are active contributing members, and the other 55 life members. The report of the Treasurer shows to you the sound financial basis on which our institution rests, and the reports of our different committees are evidence of our activity during the past year. Our publications, however, are the pride of our Society, containing, as they do, contributions from the best astronomers in every quarter of the earth. The fact of being a semi-official organ of the LICK Observatory makes them, to a certain extent, the conveyor of the important discoveries

of that great observatory. To its astronomers, and specially, to Prof. HOLDEN, the Chairman of our Publication Committee, the thanks of the Society are due.

The past year has been fertile in celestial phenomena and in discoveries made both by professional and amateur astronomers. Hardly had the new year commenced, when a new star was discovered in *Auriga*, by Dr. ANDERSON of Edinburg, an amateur astronomer. A remarkable fact in connection with this discovery is that the photographic plates exposed by Prof. PICKERING of Harvard College Observatory, had already registered the existence of the star a month before the visual observation. Probably no other star in the firmament has been so well observed, and by so many noted astronomers, as the *Nova* in *Auriga*. I will not detain you with a description of its vicissitudes, as you have already read in our transactions the master descriptions of Mr. CAMPBELL and other members of our Society.

Following the discovery of *Nova Aurigæ* came the great Sun spot of February 1st, observed by Mr. HUSSEY, and independently discovered with the naked eye by the President of our Society. That great spot, one of the largest ever seen, covering, as it did, 2.850 millionths of the Sun's visible surface, was accompanied by violent and characteristic magnetic disturbances and by brilliant auroræ.

One of the most interesting phenomena during last year was the opposition of *Mars*. Of all the celestial objects, this is the most romantic, being the favorite subject of imaginative astronomers. A look at that neighboring planet with a good telescope reveals the existence of two white polar caps and of markings on its surface, giving it a certain appearance not unlike that of our own Earth. The existence of an atmosphere, together with that appearance, has, no doubt, suggested to some the idea of its inhabitants.

It is not, then, wonderful that the popular mind was excited at the coming of the opposition of *Mars*, and that sensational discoveries were impatiently expected. For the thinking astronomer, no such discoveries were anticipated, realizing that at its nearest position from our planet it would still be 35,000,000 miles away, which, even with the best telescopes, would be as if we would look at Europe from America placed seven times apart.

Many interesting observations of *Mars* were made during the

time of its opposition, especially at the LICK Observatory, where SCHIAPARELLI'S discovery of 1877, viz., the so-called "canals" were confirmed.

The members of the Society will soon have an opportunity of judging of the work done at Mt. Hamilton during the past opposition, by a series of many admirable drawings, which will be published by the observatory and reprinted in these *Publications.*

I think that the name of "canal" for the straight double lines first discovered* by the Milanese astronomer was unfortunate, specially, as there was no necessity for such a name. The Italian word "canale" first given to the dark double lines on *Mars*, means not only "canal," but also "channel" like a water-course, a narrow passage of the sea between two portions of land; a gutter; a furrow, etc. The word canal implies the work of man, channel does not. I am convinced that the great Italian astronomer intended by the word "canale" to convey the meaning of our word "channel."

The interpretation given by Prof. SCHAEBERLE to the above named markings on *Mars* would be misnamed by the word "canal," but would be well described by the word "channel." This will show the care to be taken in translating scientific papers.

No sooner had the activity in observing *Mars* diminished, when a new discovery was announced; in fact, one of the most important astronomical discoveries of this century — the fifth satellite of *Jupiter*, by Prof. E. E. BARNARD of the LICK Observatory, made at midnight of September 9.

The *Publications of the A. S. P.* had the honor to be the first to print the original telegram sent to the observatories of the world that a new satellite had been added to those attendants of the giant planet discovered nearly three centuries ago by GALILEO with a telescope made by his own hands.

A remarkable coincidence is, that while the city of Padua was doing honor to the memory of the great astronomer who had taught the new astronomy in its University, one of the youngest astronomers in the New Continent, at the youngest and best observatory, was completing the great master's discovery by adding another satellite to his list.

*These canals were first observed by Prof. HOLDEN, at Washington, in the opposition of 1875.

When we take into account that *Jupiter* is probably the planet most observed by the best astronomers with the finest telescopes, and that the small size of the new satellite, 100 miles in diameter, together with its close proximity to the planet's center, about 112,500 miles, make the observations extremely difficult, on account of the planet's glare, BARNARD'S discovery is not short of that of genius.

Subsequently the fifth satellite of *Jupiter* has been observed at Princeton College by the telescope of 23″ aperture; at the University of Virginia with the 26-inch refractor; at Dearborn Observatory with an 18½″, and by Mr. ALBERT TAYLOR with Mr. COMMON'S 5-foot reflector.

As if fortune had not sufficiently favored the young astronomer, a photograph of the Milky Way, taken by him on the night of October 12 last, showed a dark blurry spot; for most of observers, such a small spot would have been passed unnoticed; but the comet discoverer suspected the presence of one of those knights-errant of the firmament. On the following night his suspicions were confirmed, and thus, for the first time, the sensitive photographic plate revealed the existence of a new comet. This fact, in connection with the one noticed already, referring to *Nova Aurigæ*, shows what a future photography presents for the automatic registering of celestial phenomena.

If the year just passed has afforded a rich field for astronomical observations, the present year gives promise of an equally abundant harvest. Our President is now in Chile to observe the coming total eclipse of the Sun, and to confirm or disprove his own theory of the solar corona by his own observations and those of the other expeditions in the same country, and those sent to Brazil, the west coast of Africa and elsewhere. We all are expectant, and anxiously await the telegrams of April 16 with fervent wishes and sincere hopes for his success.

I wish to call the attention of our Society to the debt of gratitude we owe to Mrs. PHŒBE HEARST, even at the risk of offending her modesty, who generously has furnished the funds for the expedition, and also for creating Fellowships in Astronomy at the LICK Observatory. The latter is now giving, by authority and direction of the Regents of the University of California, the highest class of instruction to students who may be elected Fellows in Astronomy, and is filling a want keenly felt before.

The work of photographing the Moon in all its phases is being continued at Mt. Hamilton, and the negatives are being assiduously studied by Prof. WEINEK at Prague, who has been rewarded by a number of interesting and suggestive discoveries.

A new Section, called "The Mexican Section of the A. S. P." has been organized in the City of Mexico, under the rules of our Society. All the reasons presented to the Society by its first President in favor of such organizations apply forcibly to our Mexican members. On account of the great distance from our home, the only bond of fellowship is the reception of our *Publications*, which, in this particular case, are printed in a language foreign to their vernacular. The membership will largely increase, no doubt, when they effect a closer union with each other through frequent meetings and mutual aid. Such was the idea that inspired the formation of the Mexican Section.

It was my privilege to enjoy the hospitality of the principal of our Mexican members at the National Astronomical Observatory, at Tayubaya, two weeks ago. The photographs of the buildings and instruments of that institution, which I have the honor to present to our Society to-night, will show to you that the equipment is fully equal to the requirements of modern astronomy. The principal instruments are two refracting telescopes, one 15″ and the other 6″ aperture; one 8″ meridian circle of excellent workmanship; an altazimuth 3½″ and a photo-heliograph 4″ aperture. By stating that nearly all those instruments are from the workshop of Sir HOWARD GRUBB, no other recommendation is required. Chronographs and the other usual instruments, together with an excellent library, complete the outfit.

The instruments are operated by the following gentlemen: ANGEL ANGUIANO, Director and Astronomer; Messrs. FELIPE VALLE, CAMILO GONZALEZ, FRANCISCO RODRIGUEZ REY, TEODORO QUINTANO, MANUEL G. PRIETO and GUILLERMO PUGA, all members of our Society. Of their thorough knowledge of the science of astronomy I can testify, as I was present at the examination of Sr. AGUSTIN ARAGON, another of our members. The Mexican Section of our Society is therefore in good hands, and its success is assured.

Among the committees appointed last year, one was the San Francisco Observatory Committee. It has so far progressed as to secure an observatory site in the Golden Gate Park.

An observatory in this city is needed for two reasons: First,

because the people who most need to be enlightened on elementary astronomy cannot visit the great observatory at Mt. Hamilton; second, because the astronomers of that institution should be relieved from visits of the simply curious people; their time and instruments being too precious for such purpose.

It is to be hoped that the noble example of JAMES LICK, CHAS. F. CROCKER, ALEXANDER MONTGOMERY, Mrs. PHŒBE HEARST, and other patrons of astronomy, will be emulated by our numerous wealthy citizens, whose memory cannot in any better way be perpetuated than by subscribing, during the present year, sufficient funds for the San Francisco Observatory of the Astronomical Society of the Pacific.

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## ASTRONOMICAL OBSERVATIONS.

MADE BY TORVALD KÖHL, AT ODDER, DENMARK, IN THE YEAR 1892.

### VARIABLE STARS.

*Z Cygni.*

August 19 . . . . . Z invisible in the 3-inch STEINHEIL, power 42.
" 24 . . . . id.
September 14. . . id.
" 18. . . Z < e, extremely faint.*
" 28. . . Z < e, yet constantly visible.
October 9 . . . . . . Z = e.
" 14 . . . . . . id.
" 18 . . . . . . Z a little > e.
" 19 . . . . . . Z plainly > e.
" 25 . . . . . . Z perhaps a little > a.
November 10. . . { Z > b. Z < 26.
" 18. . . id.
" 21. . . id.
" 25. . . id.
" 29. . . id.
December 16. . . id., perhaps a little decreasing.

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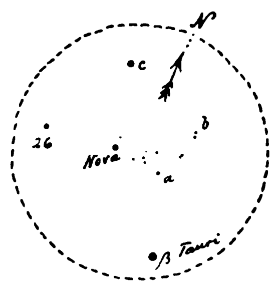
* Vide *Publications A. S. P.*, No. 22, pp. 62, 63.

*T Ursæ Majoris.*

September 28...T < f.
October 25.....id.
November 21...id.

*Nova Aurigæ.*

February 12, $7^h$ $30^m$ P. M...*Nova* a little > c > 26.
" 13, $7^h$ $30^m$ P. M...*Nova* = 26.
" 14, $9^h$ P. M. .....*Nova* apparently brighter again and = c.
" 16, $7^h$ P. M. .....*Nova* < 26.
" 19, $9^h$ P. M. .....*Nova* > 26, perhaps = c.
" 22, $8^h$ P. M. .....*Nova* is decreasing.
" 24, $7^h$ $30^m$ P. M...*Nova* = a.
" 25, $7^h$ $30^m$ P. M...*Nova* a little > a.
March 3, $8^h$ P. M..........*Nova* fainter than a, and yellow.



Nova Aurigae.

Many other parts of constellations, where variable stars were supposed to be situated, have also been reviewed in this year, and new maps are constructed for the purpose of investigating such stars.

THE LUNAR ECLIPSE OF MAY 11.

*h. m. s.*
10 1 00 P. M...The shadow is touching the eastern limit of the Moon 82° from the North. During 10 minutes the penumbra had been visible with a low power.
10 8 30 P. M...The shadow touches *Aristarchus*, and the middle of *Grimaldi*.
10 14 00 P. M...The shadow is touching *Heraclides* and *Kepler*.
10 17 30 P. M...The shadow is touching *Laplace*.

10 23 30 P. M. . . The shadow is touching *Plato, Copernicus* and eastern wall of *Gassendi.*
10 28 00 P. M. . . The shadow is touching *Archimedes.*
10 34 00 P. M. . . The shadow is touching *Aristoteles.*
10 43 00 P. M. . . The shadow is touching *Menelaus.*
10 45 00 P. M. . . The shadow is touching *Posidonius.*
10 58 00 P. M. . . The shadow is touching *Proclus*, eastern limit of *Mare Crisium.*
10 59 00 P. M. . . The shadow is touching the eastern wall of *Tycho.*
11 0 30 P. M. . . The shadow is touching the western wall of *Tycho.*
11 2 00 P. M. . . The shadow is touching the middle of *Mare Crisium.*
11 5 00 P. M. . . The shadow is touching the western limit of *Mare Crisium.* The dark part of the Moon is now very red.
11 17 00 P. M. . . Breadth of the light part 4′.
11 23 30 P. M. . . Breadth of the light part 3′.
11 31 30 P. M. . . Breadth of the light part $<2'$.
11 42 00 P. M. . . Breadth of the light part 1′.3.
12 11 00 A. M. . . The shadow is touching the southern limit of *Tycho.*
12 16 45 A. M. . . The shadow is touching the southern wall of *Gassendi.*
12 20 00 A. M. . . The shadow is touching the northern wall of *Gassendi.*
12 35 00 A. M. . . The shadow is touching *Kepler.*
12 40 00 A. M. . . The shadow is touching *Aristarchus.*
12 44 45 A. M. . . The shadow is touching *Copernicus.*
12 52 30 A. M. . . The shadow is touching *Heraclides.*
12 57 30 A. M. . . The shadow is touching *Laplace.*
1 00 30 A. M. . . The shadow is touching *Archimedes.*
1 4 00 A. M. . . The shadow is touching *Plato.*
1 15 00 A. M. . . The shadow is touching *Posidonius.*
1 17 00 A. M. . . The shadow is touching *Proclus.*
1 27 00 A. M. . . The shadow is touching the western limit of the Moon 41° from the North.

At maximum $\frac{21}{22}$ of the Moon's diameter was overshadowed. The weather here was beautiful.

SHOOTING STARS.

| No. | Time, P. M. | Beginning. | End. | Magnitude. | Note. |
|---|---|---|---|---|---|
| | h. m. s. | | | | |
| 1 | August 19 . . 12 10 | 105° + 72° | 188° + 70° | 1 | Train. |
| 2 | 20 . . 9 19 | 2 + 50 | 356 + 32 | 2 | |
| 3 | 9 34 | 47 + 54 | 55 + 49 | 3 | |
| 4 | 21 . . 9 36 30 | 17 + 52 | 16 + 47 | 3 | Fast. |
| 5 | 10 1 15 | 17 + 61 | 15 + 56 | 3 | |
| 6 | 10 24 | 22 + 42 | 30 + 43 | 4 | |
| 7 | 10 47 30 | 30 + 60 | 43 + 63 | 3 | |
| 8 | 11 18 15 | 7 + 52 | 20 + 57 | 4 | |
| 9 | 11 29 10 | 341 + 51 | 349 + 44 | 2 | Increasing from 4. to 2. Magn. |
| 10 | 11 38 15 | 314 + 38 | 318 + 47 | 3 | |
| 11 | 12 5 30 | 7 + 29 | 349 + 25 | 2 | Crossing α *Andromedæ*. |
| 12 | 12 10 40 | 4 + 14 | 357 + 6 | 3 | |
| 13 | 12 29 15 | 349 + 14 | 339 + 8 | 4 | |
| 14 | 1 1 | 54 + 37 | 54 + 33 | 4 | |
| 15 | 22 . . 9 19 5 | 335 + 53 | 321 + 39 | 4 | |
| 16 | 22 . . 10 13 40 | 318 + 55 | 307 + 39 | 4 | Crossing α *Cygni*. |
| 17 | December 21 . 6 13 | 315 + 14 | 329 + 0 | 2 | Train, slow. |

*No. 8.* This meteor has also been observed at Copenhagen in the position: 236° + 47 x — 225° + 39°, 2. Magn.

*No. 9.* Observed at Copenhagen in position: 244° + 32° x —> 244° + 25°, 2. Magn.

*No 11.* Observed at Copenhagen in position: 280° + 36° x —> 262° + 26°, 1. Magn.

The named three meteors have given the following results:

| No. | Method. | Beginning. | | | End. | | | Real Length of the Path |
|---|---|---|---|---|---|---|---|---|
| | | h | λ | φ | h | λ | φ | β |
| *8* | Construction | | | | 66 | 1° 44′ | 56° 12′ | |
| | Calculation . | | | | 59 | 1 53 | 56 8 | |
| *9* | Construction | 98 | 2° 4′ | 55° 55′ | 70 | 1° 56′ | 55° 49′ | 40 |
| | Calculation . | 95 | 1 38 | 56 2 | 72 | 1 39 | 55 57 | |
| *11* | Construction | | | | 76 | 2° 0′ | 55° 38′ | |
| | Calculation . | | | | 64 | 2 24 | 55 43 | |

Odder is situated in 2° 25′ W. long. from Copenhagen and 55° 58′ N. lat.

h and β indicate kilometres; λ is W. long. from Copenhagen; φ, N. lat.

On November 9, $5^h$ $15^m$ P. M., a splendid fireball was seen here and from several other places in Denmark, but the cloudy weather made any exact observations impossible.

A NEW REPETITION OF FOUCAULT'S PENDULUM EXPERIMENT.

On the 20th, 21st, 22d and 23d of July, 1892, I made a public trial of FOUCAULT'S Pendulum Experiment in the King's Chapel of Christiansburg, at Copenhagen. The pendulum had a length of 30 metres and weighed 35 kilogrammes, the cylinder being of lead. The whole arrangement was the same as that mentioned in the *Publications of the Astronomical Society of the Pacific*, No. 24, pp. 133, 134, with the difference that a long table was placed below the pendulum in order to show the turning of the ground in a more convenient manner. The whole series of experiments was witnessed by about 1000 spectators.

ODDER, DENMARK, January 7, 1893.

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## AN EASY METHOD OF ADJUSTING AN EQUATORIAL TELESCOPE.

By ROGER SPRAGUE.

It will be well to say in advance that this paper is only intended for the amateur astronomer. The method of adjusting an equatorial here discussed is one which could be very easily thought out in a few minutes by the experienced practical astronomer or mathematician who might chance to be placed in circumstances which would render such a method advisable or necessary. The only reasons for presenting it at all are that it is described in no standard work easily accessible to the amateur astronomer (indeed, I have never seen it in print anywhere), and it is certainly the easiest and simplest method possible, being quite accurate enough for all ordinary purposes, provided the instrument be well made.

The first thing to do in adjusting an equatorial is to adjust the finder. This is done by turning the telescope on some bright star, or distant object, and bringing said object into the center of the telescopic field. The finder is then adjusted by means of the screws provided for the purpose until the intersection of the cross-wires is exactly upon the object at the same time that it is in the middle of the field of the telescope.

The second thing to do is to find the index-error or meridian reading of the hour circle. This is best done by SCHAEBERLE'S method, which may be found in full on page 136 of Prof. CAMPBELL'S *Practical Astronomy*, two copies of which are in the library of the A. S. P., or in *Astronomische Nachrichten*, No. 2374. But as it may not be convenient for every one to refer to those publications, I shall briefly recapitulate the method here. A stick is first fastened across the middle of the object end of the telescope (or of the finder if extreme accuracy is not desired, but rather a gain of convenience). This stick must be roughly parallel to the declination axis, and to the end opposite to the declination axis a string must be fastened, which must be led down through that one of the capstan-headed screws used to adjust the finder, which is opposite to the declination axis. This screw must, of course, be turned until the hole through it is parallel to the optical axis of the telescope. To the lower end of the string is attached a plumb-bob, which is finally allowed to swing in a vessel of water. The telescope is then brought into such a position (nearly vertical) that the string will swing free of the sides of the hole. The instrument is then clamped so that the string is as near as may be in the exact center of the hole, and the verniers of the hour circle read. The telescope is then reversed to the opposite side of the pier, being very careful not to disturb in any way the attachment of the string to the object end of the telescope, and the hour circle again read. The mean of the readings of the hour circle in the two positions gives the reading of the circle when the instrument is in the meridian. The meridian reading of each vernier should be determined separately to avoid confusion.

To adjust the instrument in azimuth, the hour circle is set at its meridian reading and the instrument clamped in right ascension a little before *Polaris* passes upper or lower culmination. The telescope is left unclamped in declination, and by swinging the tube in declination it is brought to point as nearly as possible on *Polaris*. It can then be easily seen by glancing along the tube whether the telescope is pointing too far to the east or west, and it is possible to move it in azimuth by means of the adjusting screws until *Polaris* is brought into the field of the finder and then into the field of a high power eye-piece (the higher the power the better) on the equatorial itself. At the time, as near as may be, when *Polaris* crosses the meridian the star is brought into the center of the field, and the adjustment in azimuth is complete.

To adjust the instrument in altitude, it is clamped in right ascension six hours off of the meridian, and when *Polaris* approaches eastern or western elongation the instrument is again swung in declination until it is pointing as nearly as possible to the star. It is then possible, by glancing along the tube, to see whether it is pointing too high or too low, and to correct this error by changing the inclination of the polar axis until the star is brought into the center of the field of view at the minute when the star is six hours off the meridian. The adjustment of the instrument is then complete.

The sidereal time for the upper culmination of *Polaris* is given for every day in the year in the *American Ephemeris*, pages 302–313. Those who do not possess a sidereal chronometer will need to know how to change this sidereal time into mean time. The process can be best illustrated by an example. Suppose we wish to find the mean time when *Polaris* shall cross the meridian of San Francisco on the night of April 15, 1893. Turning to page 57 of the *Ephemeris*, we find that the sidereal time of mean noon at Greenwich on April 15 is $1^h\ 35^m\ 28^s$. To find the sidereal time of mean noon at San Francisco on that date we take the longitude of San Francisco in time ($8^h\ 9^m$) and go with it to Table III, page 526. Placed opposite to $8^h\ 9^m$ we find $1^m\ 20^s$. This added to the $1^h\ 35^m\ 28^s$ gives us the time we want, or $1^h\ 36^m\ 48^s$. Next, turning to page 305 of the *Ephemeris* we find that *Polaris* crosses the meridian at $1^h\ 18^m\ 24^s$, sidereal time. From this time (plus $12^h$ for lower culmination) we subtract the $1^h\ 36^m\ 48^s$ and get $11^h\ 41^m\ 36^s$. Taking this time to Table II, page 523, we find placed opposite it $1^m\ 55^s$. Subtracting this from $11^h\ 41^m\ 36^s$ gives $11^h\ 39^m\ 41^s$. This is the mean time for the lower culmination of *Polaris* at San Francisco on the night of April 15. To change this to Pacific standard time we must add $9^m$. The whole example may be stated as follows:

| | *h.* | *m.* | *s.* |
|---|---|---|---|
| April 15, sidereal time (at Greenwich mean noon) . | 1 | 35 | 28 |
| Reduction for $8^h\ 9^m$ in Table III . . . . . . . . . | | + 1 | 20 |
| Sidereal time of local mean noon . . . . . . . . . | 1 | 36 | 48 |
| Given sidereal time (+ $12^h$ if necessary) . . . . . . | 13 | 18 | 24 |
| | 11 | 41 | 36 |
| Reduction for $11^h\ 41^m\ 36^s$ in Table II . . . . . . . | | − 1 | 55 |
| Required mean time . . . . . . . . . . . . . . . . | 11 | 39 | 41 |
| Reduction to standard time . . . . . . . . . . . | | + 9 | |
| Required standard time . . . . . . . . . . . . . | 11 | 48 | 41 |

In this example the time has in no case been taken closer than seconds, as this is more than sufficiently accurate for the purpose. Practically a watch error of $\pm$ $2^m$ would be perfectly allowable, as it would not vitiate the adjustment by as much as a minute of arc, an insignificant amount.

The principal advantage of this method of adjustment is that it does away altogether with the use of the finely divided declination circle. As the reading of this circle is always the most laborious and lengthy part of any ordinary method of adjustment, and is the especial dread of amateur astronomers, the importance of this point need not be dwelt on.

Napa College, Napa, Cal.,
March 21, 1893.

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## MISCELLANEOUS OBSERVATIONS OF *NOVA AURIGÆ*.

By W. W. Campbell.

(*a*). In the *Monthly Notices of the Royal Astronomical Society* for January Dr. Isaac Roberts gives the following account of his attempts to photograph any nebulosity that may be connected with *Nova Aurigæ*:

"A photograph of the region of *Nova Aurigæ* was taken on October 3, 1892, with the 20-inch reflector, and exposure of 110 minutes, upon which the *Nova* appears as a star, as well defined as any of the other stars, which are very numerous, on the plate. There is no trace of nebulosity surrounding the *Nova*, or in its vicinity, and there is no feature about it suggestive that it is different from other stars. The diameter of its photo-image measures 21 seconds of arc, and about 85 seconds distant from it, on the north-following side, is a star, the photo-image of which measures 23 seconds of arc; the *Nova* is therefore 2 seconds in diameter less than the star.

"On December 25, 1892, another photograph was taken of the same region, with an exposure of 20 minutes, upon which the *Nova* has a photo-image of 13 seconds of arc, and the star referred to has a diameter of 16 seconds.

*   *   *   *   *   *

"So far, therefore, as the evidence obtained by the eleven photographs which I have taken between the date of the appearance of the *Nova* and December 25, there is nothing upon them indicative of a disturbance, such as we might expect to see recorded if a body of the magnitude and velocity of the *Nova* had rushed into a nebula, or into a swarm of meteors." * *

Negatively, these photographs are of great interest, for several reasons:

(1). In *Astronomische Nachrichten* No. 3118 Prof. SEELIGER explained the observed spectrum of *Nova* during February and March, 1892, on the hypothesis that a very faint or dark body had passed swiftly through one of those large tenuous nebulosities which the excellent photographs obtained by Herr MAX WOLF of Heidelberg show to be very extensive in many parts of the sky. If such a nebula surrounds *Nova*, it must be exceedingly faint to have escaped detection by Dr. ROBERTS' telescope with long exposure.

(2). The smaller image shows it to be considerably fainter photographically than the star 85 seconds distant, though visually the *Nova* is at least half a magnitude brighter than the star. These results had also been reached here by Prof. SCHAEBERLE, and at Greenwich. They were to be expected from the distribution of the light in its nebular spectrum, nearly all the light falling at the wave lengths 575, 500, 496 and 486, which are in regions only slightly actinic.

(3). In the 36-inch equatorial the *Nova* is plainly seen to be nebulous and about 5 seconds of arc in diameter. As we construe Dr. ROBERTS' paper, he contends from his photographic evidence that the *Nova* is not nebulous. Since the photo-images are from 13 to 21 seconds in diameter, we do not see how they can have any bearing upon the question of the character of the *Nova*, which is probably not much over 5 seconds in diameter. I would suggest that the value of the evidence be tested by photographing some planetary nebula resembling the *Nova* in magnitude and structure, for example, N. G. C. 6790, and comparing the nebular image obtained with that of a star slightly fainter (visually).

(*b*). In the *Observatory* for January the Astronomer Royal for England called attention to a remarkable diminution of the brightness of the *Nova*. He said: "The photographs [for

magnitude] were discontinued at Greenwich on September 6, and the *Nova* was noted as invisible in the 10-inch finding telescope about October 7 by Mr. TURNER, October 22 by Mr. DAVIDSON, and on October 25 by Miss EVERETT. This would imply that the *Nova* was below the 14th magnitude. * * * On November 30 it was estimated by Mr. TURNER and Mr. DAVIDSON as 0.9 magnitude *brighter* than the comparison star, so that it would appear to have risen between October 25 and November 29 from below the 14th to about 8.5 magnitude, and this is the second time such a brightening has been noted."

The above results are widely at variance with those secured here and elsewhere during October. I observed it visually with the 4-inch finder on October 12, 19 and 22, and spectroscopically with a grating on October 12 and 19, and no significant decrease in brightness was detected. Prof. BARNARD observed it with the 36-inch on October 21, 23 and 25. In his opinion, since August the object has "as a whole remained essentially constant in its light." At Oxford, England, on October 5, 7 and 10, the magnitude was estimated at 9.5; on October 19 at 9.7; and on October 25 at 9.8. It is impossible to harmonize the observations made here and at Oxford with those made at Greenwich on the same nights, unless, indeed, we grant that the *Nova* varied 4.5 magnitudes in a few hours. If it is granted that such a variation has occurred, it must have very great significance in the finally accepted theory of the *Nova*.

(*c*). In *Astronomische Nachrichten* No. 3129 and *Astronomy and Astro-Physics* for January, Herr EUGEN von GOTHARD compares, in an interesting manner, the spectrum of *Nova* with the spectra of eight well-known planetary nebulæ. As had already been found by observations made here, the spectra of the *Nova* and of the nebulæ are practically identical. Herr von GOTHARD's observations were made photographically in September and October in a novel way. In front of the 10¼-inch reflecting telescope already arranged for ordinary stellar photography he placed a thin 10-inch-square prism. The image of the *Nova* formed on the sensitive plate was its spectrum, of which eight bright lines were recorded by long exposure. Not using a slit spectroscope, he was of course unable to measure the velocity of *Nova* in the line of sight. The small dispersion employed gave a spectrum only 3 mm. long from λ 580 to λ 373, and

hence the wave lengths could not be measured accurately. The wave lengths of the bright lines photographed he gives as below:

| Nebulæ. | I. | II. | III. | IV. | V. | VI. | VII. | VIII. |
|---|---|---|---|---|---|---|---|---|
| G. C. No. 4447 . . . | — | 502 | — | 434 | 411 | 396.5 | 386.5 | 373 |
| " 4964 . . . | — | 501 | 470 | 434 | 409 | 397 | 386.5 | — |
| " 4373 . . . | — | 502 | — | 434 | 410 | 396.5 | 386.5 | 373 |
| " 4514 . . . | — | 502 | — | 434 | 410 | 396.5 | 385.7 | 371 |
| " 4628 . . . | — | 501 | 468 | 434 | 408.5 | 396 | 386.5 | 372 |
| N. G. C. No. 7027 . . . | — | 500.7 | 464 | 434 | 410 | 395 | 385.7 | — |
| " 6891 . . . | — | 502 | — | 434 | 410 | 396 | 386.5 | 372 |
| " 6884 . . . | — | 500.5 | — | 434 | — | 395 | 386.5 | — |
| *Nova* . . . . . . . . . | 582 | 500 | 464.2 | 434 | 407.7 | 395 | 385.5 | 372 |

The line λ 582 is the same line observed by me at λ 5750. It does not appear in the nebular spectra preceding, and is not known to exist in any other spectrum.

Herr von GOTHARD calls attention to the very different intensities assigned to the bright lines by himself and by me, and suggests that they are due to the very general absorption of the violet rays by the 36-inch objective. The true explanation, however, is entirely different. My estimates are *visual*, while his are *photographic*, and based upon the very peculiar curve of sensitiveness of orthochromatic plates. The brightest line shown on my photographs is that at λ 4360, as it also is on his plates, though he assigns a wave length 4340 and uses it as the origin of measurements for the whole spectrum. If to this line he assign the correct wave length 4360 the apparently erroneous position of the line H δ (λ 4077) is explained.

The results of the studies have been summarized as follows by von GOTHARD:

(1). The spectra of the planetary nebulæ agree typically, although they differ slightly in the intensities.

(2). Hydrogen is represented in each spectrum by three or more lines, viz: λ 434, λ 410, λ 397.

(3). Besides the hydrogen lines the presence of two characteristic nebular lines λ 5006 and λ 3867 can with certainty be proved in all, a third λ 3727 in most spectra. The fourth line λ 464–470 seems to be less frequent.

(4). Line λ 3727, which is always very intense in the large irregular nebulæ, is always very faint in the true planetary nebulæ, which fact marks a considerable difference between the two kinds.

(5). In each spectrum can be detected a more or less developed continuous spectrum, corresponding to a nucleus or a condensation.

(6). The physical and chemical state of the new star resembles at present that of the planetary nebulæ.

From observations made here, at Harvard and elsewhere, all of these results were well known except the fourth; and that is just the opposite of what would naturally have been expected from Dr. HUGGINS' photographs of the *Orion* nebula spectrum. He found that this line λ 3727 was relatively much brighter for the condensed portions of the nebula than for the diffused.

(*d*). I have remeasured the position of the yellow line, in connection with some work on WOLF-RAYET stars, and have obtained for it:

1893, February 15 . . . λ = 5752,
" " 18 . . . λ = 5751.

The finally adopted wave lengths for the yellow lines in the WOLF–RAYET spectra will differ very little from 5876, 5813, 5692 and 5594.

(*e*). There are several additions and corrections to be made to the list of wave lengths as published in the last number of the *Publications*. The amended list is given below. Those marked thus (*) were determined by Mr. TOWNLEY:

| | | | |
|---|---|---|---|
| 1892, Dec. 13* | λ = 5004.2 | Velocity = | — 107 miles. |
| " 14* | 5004.1 | | — 109 |
| " 18* | 5006.3 | | — 29 |
| 1893, Feb. 10 | 5006.2 | | — 30 |
| " 14 | 5006.1 | | — 33 |
| " 27 | 5005.7 | | — 52 |

In Mr. TOWNLEY'S observing notes I find: for December 13, "wind nearly 60 miles per hour," observations few and discordant; for December 14, "wind 50 miles per hour," observations discordant; and for December 18, "very little wind," observations very accordant, adjustments tested on solar spectrum next morning. It is evident that the observations of December 13 and 14 are entitled to very small weight. It is quite probable that the wave lengths were considerably larger in the two months when no observations were made.

In any discussion of these observations it is necessary to take into account the difficulty of accurately bisecting a line as broad and diffuse as this one is. The error in the result for any night can scarcely exceed 10 miles per second, and there can be no doubt of the reality of the change in wave length. If it is due to orbital motion, a very unusual orbit will be required to satisfy the observations.

(*f*). A recent note in *Astronomische Nachrichten* by Dr. HUGGINS describes the chief nebular line of *Nova's* spectrum as multiple, consisting of several fine bright lines very close together.

On August 30 this line was suspected to be double, at Mt. Hamilton, and on September 7 the line was thought to have a still different form. Later observations did not confirm my suspicions. On November 7 it was examined under the great dispersion of a fourth order grating and seen to slope equally and uniformly in both directions.

(*g*). Two very important contributions to the spectroscopic history of the *Nova*, during February and March, 1892, have recently been published: one by Herr A. BELOPOLSKY of Pulkowa in the *Bulletin de l'Académie Impériale des Sciences de St. Pétersbourg*, and the other by Father SIDGREAVES of the Stonyhurst Observatory (England) in the *Memoirs of the Royal Astronomical Society*. Both papers contain very extensive lists of bright and dark lines. Between the several catalogues of observed wave lengths obtained by different observers there is not that degree of accordance which could be wished for. However, there is a better agreement than at first appears. Many apparent discrepancies are removed by considering that in this spectrum a large number of lines shown to be single under weak dispersion are shown to be multiple under strong dispersion. The wave length given by one observer will frequently for this reason be found to be the mean of the wave lengths for two or more finer lines measured by another observer.

The observations of Herr BELOPOLSKY certainly support the theory that the *Nova* consisted of two or more bodies moving with very different velocities, while Father SIDGREAVES considers that his observations argue in favor of the one-star theory of *Nova*.

(*h*). Micrometer observations made by Prof. BARNARD on several nights since August to determine whether the *Nova* was

moving with reference to the small stars near it (see *Astronomiche Nachrichten* No. 3143) make it probable that a very slight displacement has occurred; too slight, however, to say that the observed variations are not due to unavoidable errors of observation.

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## EVOLUTION OF THE DOUBLE-STAR SYSTEMS.

By Dr. T. J. J. See, University of Chicago.

[Abstract of a paper read before the Chicago Academy of Sciences, February 7, 1893.]

Sound cosmogonic speculation begins with KANT, who was the first of modern philosophers to advance a definite mechanical explanation of the formation of the heavenly bodies,* and particularly of the bodies composing the solar system. The views of KANT do not seem, however, to have received much scientific recognition until after LAPLACE'S independent formulation, in more exact mathematical terms,† of a similar explanation of the origin of the planetary system, based upon remarkable phenomena observed in the motions of the planets and satellites, and known as the nebular hypothesis.

Partly on account of the overwhelming‡ argument of LAPLACE in favor of a *natural* or *mechanical* explanation§ of the origin of the planetary system, and the sound dynamical conception underlying the great geometer's hypothesis, and partly on account of the keen interest and speculation arising out of Sir WILLIAM HERSCHEL'S epoch-making investigations of the nebulæ, the nebular hypothesis was soon accepted by astronomers as an explanation entitled to scientific belief. The classic researches of Sir JOHN HERSCHEL tended still further to establish confidence in LAPLACE'S view of the nebular origin of the heavenly bodies; but when Lord ROSSE'S great reflector showed the discontinuous

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* See KANT'S *Allgemeine Naturgeschichte und Theorie des Himmels*, published in 1755; *Sämmtliche Werke*, Vol. I, p. 207.

† See *Système du Monde*, Note VII et dernière, p. 498.

‡ See LAPLACE'S remarks in the Introduction to his *Théorie Analytique des Probabilités*, p. 67.

§ NEWTON regarded the planets as having been set in their orbits by the immediate hand of the Deity, and held that the fixed stars had been intentionally placed at such vast distances apart in order that they might not fall upon one another by their mutual gravitation. See his remarks in the *Scholium Generale*, p. 527, of Sir WILLIAM THOMSON'S edition of the *Principia*.

nature of some of the objects then classed as "nebulæ," the question arose, whether, with sufficient power, all "nebulæ" might not be resolved into discrete stars. Fortunately, the invention of the spectroscope about 1860, and Dr. HUGGINS' application of it to the study of the heavenly bodies, at once answered this question in the negative, by showing that many of the nebulæ are masses of glowing gas in the process of condensation; and hence it then became a matter of great scientific interest to investigate the formation of the heavenly bodies.

The principle of the conservation of energy and the mechanical theory of heat, which HELMHOLTZ was the first to apply to the nebular contraction of the Sun,* and LANE'S researches on condensing gaseous masses,† together with the researches of Sir WILLIAM THOMSON on the Sun's age‡ and heat, have each marked important epochs in the development and confirmation of the nebular hypothesis as now maintained and generally accepted by astronomers. The nebular origin of the heavenly bodies being at present generally conceded, the main question of interest relates to the *process* involved in the development of cosmical *systems*.

The nebular hypothesis of LAPLACE supposes the planets and satellites to be the condensed products of rings successively shed by the contracting nebula which originally contained the matter of the solar system, and this theory of ring-formation has exercised extraordinary influence over the minds of scientific men. Prior to the researches of Prof. G. H. DARWIN on the origin of the lunar-terrestrial system, the theory of ring-formation appears never to have been seriously questioned, at least as respects the planetary evolution. But Prof. DARWIN'S discovery of the exceptional formation of the Moon, and his introduction of the important physical agency of tidal friction (which was entirely overlooked by LAPLACE) necessitated considerable modification of the original nebular hypothesis, and constituted, perhaps, the most important step in scientific cosmogony made during this century. Since tidal friction is a necessary adjunct of gravitation wherever systems of fluid bodies exist in a state of relative

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* See the Popular Lecture delivered on the occasion of the KANT Commemoration at Königsberg, February 7, 1854.

† See *American Journal of Science*, July, 1870.

‡ See *Popular Lectures and Addresses* of Sir WILLIAM THOMSON, Vol. I, p. 349.

motion, we perceive that it is a physical agency as universal as gravitation itself, operating more or less powerfully in all the systems of the universe.

It is but proper to state, however, that Prof. DARWIN'S researches on tidal friction were applied only to the solar system, in which the conditions are highly unfavorable to the theory (except in the case of the Earth and Moon), chiefly on account of the relatively small masses of the attendant bodies. In the stellar systems, where each body is sufficiently large to have a considerable moment of momentum of axial rotation, the secular effects of tidal friction must be of far greater importance, and it will therefore not be surprising if we find that this physical agency has played a more prominent part in the development of such systems than even in the case of the Earth and Moon.

It may be remarked that nearly all the cosmogonic speculations hitherto promulgated have been advanced with especial reference to the solar system. For it appears that no systematic investigation of the origin of double stars was ever attempted prior to my own researches, which were begun in an elementary manner about four years ago.

The first step in the investigation was the collection of a table of the best orbits available, which were found to be highly eccentric in comparison with the orbits of the planets and satellites. It was at once evident that so remarkable and fundamental a difference could not be overlooked in explaining the origin of double stars, and the high eccentricities seemed to point with overwhelming probability to the operation of some powerful physical cause which had not left a corresponding impress upon the orbits of the planetary system. Accordingly, it occurred to me that the cause which had elongated the double star orbits might be the secular gravitational reaction arising from tidal friction in the bodies of the stars — an hypothesis that has been confirmed by subsequent mathematical research, in which methods were followed analogous to those employed by Prof. G. H. DARWIN in his graphical history of the system of the Earth and Moon. I had seen no intimation that tidal friction could increase the eccentricity, but soon proved it for the case in which the tides lag (less than 90°), only to discover afterwards that a similar result had been reached by Prof. DARWIN several years earlier,*

* See article "Tides," *Encyclopedia Britannica*, Vol. XXIII, p. 378; also, Prof. DARWIN'S well-known papers in the *Philosophical Transactions and Proceedings of the Royal Society*, from 1878 to 1882.

though it had not been given any particular prominence, and was apparently but little known; hence the discovery that tidal friction could increase the eccentricity was an independent one, since at that time my knowledge of Prof. DARWIN'S work was based upon a review* which gave no account of the secular changes of the eccentricity arising from tidal friction.

In the present discussion of the working of tidal friction, we shall merely present some of the secular effects in an elementary geometrical manner, and at length give a sketch of the process by which double stars arise from double nebulæ.

Self-luminous bodies, such as the Sun† and double stars, are certainly in a fluid state (the term *fluid* being used in the most general sense), and there is reason to believe that the *viscosity* or "stiffness" of the fluid is usually small. Therefore, the tides raised in such masses by the attraction of foreign bodies will not be confined to the surface (as in case of the fluid oceans surrounding the nearly rigid Earth), but will extend throughout the whole mass; such tides are termed *bodily* tides, and it is with them that we are here concerned. Now, imagine a double-star system whose components we shall call respectively *Helios* and *Sol*,‡ each of which is of the same order of mass and same general physical condition as the Sun. Suppose both stars to be spheroids endowed with rotations which are rapid compared to their period of revolution about one another, in the same direction, and about axes nearly perpendicular to the plane of orbital motion.

Let the system be started with the spheroids at a considerable distance apart, so that the attraction of either upon the other becomes practically the same as if the masses were collected at the centers of gravity, and suppose the orbit given a small eccentricity. Then, since the fluid is more or less viscous, the tides raised in either mass by the attraction of the other will lag, and if the viscosity is small the angle of the lag will be only a few degrees. For simplicity, we shall now treat the spheroid *Sol* as having its mass collected at its center of gravity, and examine the effects on the eccentricity arising from the tidal reaction of *Helios;* but it must be remembered that in general the whole

* Miss CLERKE'S *History of Astronomy during the Nineteenth Century.*

† A part of this discussion is reproduced from *Knowledge*, of May, 1892.

‡ These names are chosen to fix the attention upon a system composed of two Sun-like bodies, such as we find in double-star systems.

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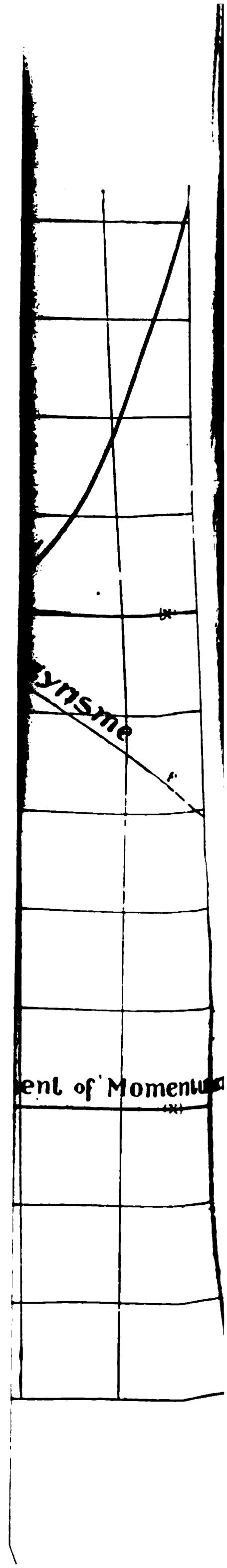

since practically the whole disturbing force due to the tides in *Helios* may then be regarded as acting in the tangent to the orbit. When the tides lag (less than 90°, as in *Fig. a*), the tangential component is directed forward, and hence tends to accelerate the instantaneous linear velocity; the force arising from a a resisting medium is directed continually backward, and hence tends to cause the instantaneous linear velocity to diminish. The two forces are, therefore, oppositely directed, and hence it is evident that if they acted simultaneously the orbit would not undergo the least change either in size or shape, but would be rigorously stable. Now, the resistance encountered at any given point of the orbit depends upon the density of the medium, and is also proportional to the square of the instantaneous linear velocity; but from KEPLER'S law of equal areas in equal times, it follows that the momentary velocity of the revolving body is inversely as the radius vector. The accelerating force due to tidal friction varies inversely as the seventh power of the distance; therefore, in order to counterbalance this by a retarding force due to resistance, we must suppose the density of the medium to vary inversely as the fifth* power of the distance from the center. Such a medium would give a resistance that would just annul the changes arising from tidal friction. Now, LAPLACE has shown † that the action of a resisting medium increasing in density towards the center, according to any law whatever, causes the major axis and the eccentricity of the orbit of a revolving body to diminish. Therefore, tidal friction must cause the major axis and the eccentricity of the orbit to increase.‡

The stellar orbits are on the average about twelve times

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* If $\sigma$ be the density of the medium, $\rho$ the radius vector, and $\kappa$ some constant, then the resistance $t'$ varies as $\kappa\sigma v^2$, but $v^2$ varies as $\frac{1}{\rho^2}$; therefore, $t'$ varies as $\frac{\kappa\sigma}{\rho^2}$. The disturbing force $t$ varies as $\frac{\kappa}{\rho^7}$. But $t'$ must be made equal to $t$, hence we must suppose $\sigma$ varies as $\frac{1}{\rho^5}$. Then $t' = t = \frac{\kappa}{\rho^7}$.

† *Mécanique Céleste*, Liv. X, Ch. VII, Sec. 18; or WATSON'S "*Theoretical Astronomy*," p. 552.

‡ We may add that the increase will usually continue until the rotations of both stars are nearly exhausted, after which the eccentricity will be reduced by the libratory motion of the system, and the orbit will at length become circular. The stars, however, would then perhaps be entirely dark, and hence, if in the immensity of space any such dark rigid double-star systems exist, they can not be observed. Other relations of rotation and revolution, and various other viscosities, give rise to various other results; but the conclusion above reached is that of chief interest in connection with the great multitude of double-stars hitherto discovered.

as eccentric as those of the planets and satellites. The mean eccentricity of the 70 orbits now roughly known is 0.45, while the corresponding mean for the orbits of the 8 great planets and their 20 satellites is less than 0.0389. The orbit of $\gamma$ *Virginis* is known with great precision, and here we have the remarkable eccentricity of 0.9; and the very trustworthy orbit of *Sirius*, recently computed by Dr. AUWERS, has the very considerable eccentricity of 0.63. From a number of other orbits whose eccentricities are very well determined, the fact seems certain that the double-star orbits are generally highly eccentric, though some few appear to be more circular, in accordance with the theory of tidal evolution, under what are perhaps abnormal conditions. Therefore, we have in the general elongation of the double-star orbits a visible trace of the action of secular tidal friction, which has played so important a part in the evolution of the stellar systems, mainly because of the large mass-ratios of the component bodies and their comparative proximity during immense ages; for it must be remembered that double stars, now condensed and widely separated, were millions of years ago much closer together and more expanded in volume, and hence the tidal action was then very much greater than at present. The conclusions here merely stated are confirmed by a rigorous research, which I have recently presented as an "Inaugural Dissertation" to the Faculty of the University of Berlin, and have published under the title "*Die Entwickelung der Doppelstern-Systeme*," to which I must beg to refer all who desire details of the mathematical treatment of the problems arising in double-star evolution.

It now remains to discuss the process by which a nebula under accelerating axial rotation splits up into two comparable masses.

M. POINCARÉ* and Prof. DARWIN† have investigated the equilibrium of rotating masses of fluid with a view of testing LAPLACE'S theory of the formation of the planets and satellites. The researches are widely different in character, but they lead to substantially the same result, namely, that when equilibrium breaks down in a rotating mass the portion detached by increasing angular velocity should bear a far larger ratio to the parent mass than is observed in the planets and satellites of the solar system; and, moreover, that while the separation might ideally

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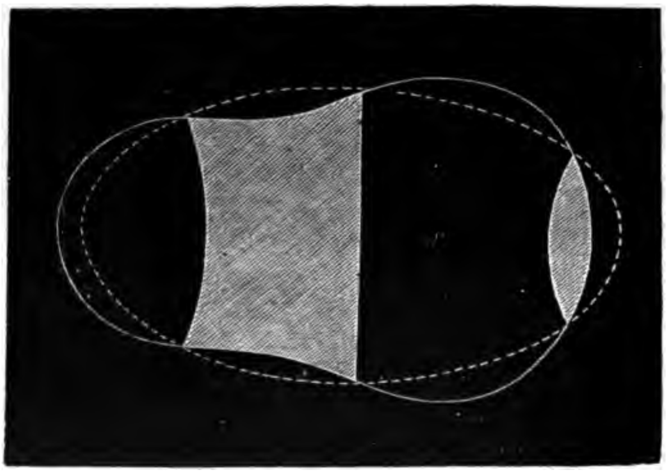
* *Acta Mathematica*, Vol. VII.

† *Phil. Trans.*, 1888.



THE APIOID OF POINCARÉ.

ke place in the form of a ring, the general process of division ould give rise to masses of a more or less globular form. The pioid of M. POINCARÉ is given in the accompanying figure, which ows the manner in which the JACOBIAN ellipsoid under increasing ial rotation becomes unstable and finally breaks up into two mparable masses, by a sort of division resembling "fission" 1ong the protozoans. That this process of separation actually curs in space will be evident on comparing the Apioid with r JOHN HERSCHEL'S drawings of double nebulæ, which are re reproduced. It seems legitimate to conclude that double bulæ have originated from single (perhaps irregular) masses the process of "fission" arising from increasing rotation, and at in the course of millions of years they will develop into uble-stars.

Double nebulæ have been greatly neglected since the time of r JOHN HERSCHEL, but it is to be hoped that astronomers will ain give adequate attention to these remarkable objects, which ould be at once systematically studied and photographed. If curate drawings or photographs of these objects were now ade, it is not to be doubted that important changes could be served fifty years hence.

Should the theory of double-star evolution here briefly and perfectly sketched prove to be substantially true, I think it will conceded that it throws considerable new light upon the prob- n of the formation of the heavenly bodies. For hitherto nearly investigators have proceeded in their researches from the point view of the solar system, notwithstanding the fact that our sys- m is very remarkable, and indeed different from any other therto discovered:

(1). *The revolving bodies are very small relative to the central dies* (except the Moon, whose mass amounts to $\frac{1}{80}$ of the Earth's ass).

(2). *The orbits are nearly circular* (we neglect asteroids and mets).

The double-star systems are remarkable for:

(1). *The large mass-ratios of component bodies.*

(2). *The high eccentricities of the orbits.*

It seems hardly credible, and yet it is a fact, that the Sun has o times the mass of all the attendant bodies combined; hence see that practically all the mass of the solar nebula has gone

into the Sun. In double-star systems, the masses, if not equal, are at least comparable. In other words, *the mass-distribution in the solar system is essentially single, whereas in the double-star systems it is essentially double.*

Therefore it is not wonderful that tidal friction has played so prominent a part in the double-star systems, and has been so unimportant in the solar system, where the masses of the revolving bodies are so small as to render their moments of momentum of axial rotation inefficient in changing the size and shape of the orbits. Considering the exceptional character of our system, are we not therefore justified in affirming that the general law of cosmical development can only be deduced from the study of other systems in space, and especially of double stars and double nebulæ, which seem to typify the normal form of celestial evolution? If so, the importance of studying double stars and double nebulæ will be the more easily perceived, as will also the interest attaching to multiple stars and clusters, which deserve the most careful study and the most systematic investigation. For if all the clusters now visible in the heavens were carefully studied and measured by means of photography, it is not to be doubted that in half a century some progress could be made towards explaining the formation of these wonderful bodies, concerning which we are at present profoundly ignorant. If adequate attention is given to other systems in space, we may be sure not only that true cosmogony will be greatly advanced, but that we shall also gain additional light respecting the formation of our own extraordinary system, whose development seems to have been somewhat anomalous. But even in the case of the solar system it is questionable whether the theory of ring-formation is applicable, except in the case of *Saturn's* rings and the asteroids, which appear to have been exceptional formations. The LAPLACEAN theory of ring-formation, although mathematically sound in principle, fails utterly when applied to the actual systems of the universe at large, as we infer from the well-known rarity of ring nebulæ and the great abundance of double nebulæ and double stars. It is to be remarked, however, that it was not known in the time of LAPLACE that a rotating mass of fluid could assume any other than symmetrical figures of equilibrium (including, of course, the *annular form*); but from the researches of POINCARÉ and DARWIN we infer that unsymmetrical figures, such as we observe in double nebulæ, are not only ideally possible, but are in general

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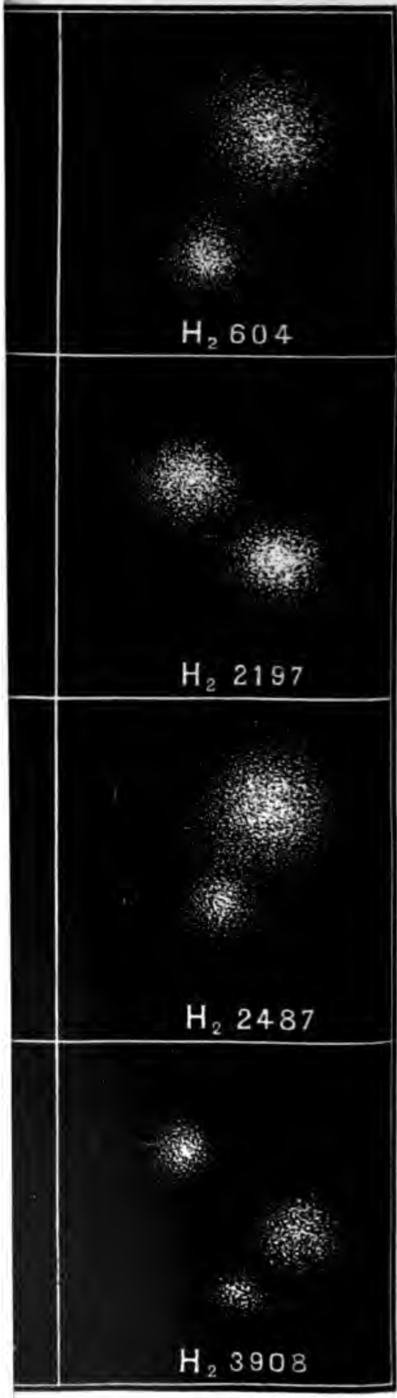


E NEBULÆ.

alized in nature. Therefore, since the planets also separated in the form of globular masses. there is no logical reason for holding the theory of ring forma- in the case of *Saturn's* rings and the asteroids, which have been exceptional.

re other nebulæ worthy of study, particularly the spiral t since their true figures remain uncertain, they have nsidered in this discussion. If adequate attention is uble, multiple and spiral nebulæ, future research will upon problems which now remain obscure, and in the me we shall perhaps be able to reach a definite conclu- ting the formation not only of our own system, but of nerally. And when sufficient data have been collected ght upon the results of theory, cosmogony ought to the plane of mere speculation to the rank of a real f we shall at present succeed in discovering the law of formation, no inconsiderable advance will have been e right direction.

ry 21, 1893.

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## TWO NEW PLANISPHERES.

By W. J. Hussey.

ly two new planispheres have been issued in this coun- by The Register Publishing Company, Ann Arbor, d the other by Poole Bros., Chicago. The former ged by Prof. Harrington, the latter by Mr. Jules A. The prices are $1.00 and $3.00 respectively.

st is much the smaller and less pretentious of the two. of the usual parts, a substantial movable disc, having llations mapped upon it, mounted on a square block of dboard, nearly nine inches on a side. The constellations ude those having north polar distances of less than 120°, ars, those of the four brightest magnitudes. A few of onspicuous nebulæ and clusters are also given. The be readily set to show that part of the celestial sphere horizon at any hour of the night on any day of the key to the positions of the planets is given on the back. ood till 1901.

The second possesses several advantages, by reason of its larger size and clearer typography. It is admirably engraved. Its movable disc is 19½ inches in diameter, and is mounted on a cardboard 19 x 23 inches. It includes the constellations, with stars of the five brightest magnitudes as far as 50° South Declination. In nearly all cases it gives the names or numbers of the stars. It also gives a large number of clusters and nebulæ. Double and multiple stars are distinguished from others by a small dash printed near them.

The only circles on this planisphere are those indicating the positions of the ecliptic and celestial equator. A device is given by means of which approximate Right Ascensions may be obtained. A string representing the meridian is stretched across the disc from the top to the bottom of the planisphere. The Right Ascensions are printed around the circumference of the disc. A star whose Right Ascension is sought being brought under the string, will have its Right Ascension indicated at the circumference at the point under the string. No means is given for obtaining the declinations.

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## A CELESTIAL HANDBOOK.

By W. J. Hussey.

As a companion to his planisphere, Mr. Colas has prepared a *Celestial Handbook* of 110 + xiii pages. It is published by Poole Brothers, Chicago. Price, $2.00.

It begins with several pages of introductory matter of an elementary character on the magnitudes, distances and classification of the stars and on the precession of the equinoxes. Then ninety-one pages are devoted to the constellations having north polar distances less than 140°; six pages to a variety of tables, including a list of the constellations, the names of the principal stars, the principal binary stars, the finest colored double stars, stars for which a parallax has been found, etc.; and, finally, excepting indices, five pages to shooting stars, comets and the planets.

The account of each constellation begins with a very short description. This is followed by a list of its lucid stars, including their magnitudes and approximate positions for 1880, and then by notes on the more interesting stars, nebulæ and clusters.

In the notes, especial prominence is given to double stars and to stars for which a parallax has been found. In these particulars they are apparently trustworthy. Some of the other notes, however, are not of a character that inspires confidence. They seem to have been picked up second-hand and not to have been selected from original sources, and not always in the light of the most recent investigations.

Five satellites are attributed to *Jupiter*. It thus takes account of Professor BARNARD'S brilliant discovery of last September. The reappearance of *Nova Aurigæ*, however, is not mentioned, and, consequently, nothing is said of its nebulous character as demonstrated spectroscopically by Professor CAMPBELL and (independently, the same night) visually by Professor BARNARD. The velocity of *Arcturus* in the line of sight is given 3,100 miles per minute. In 1890, Professor KEELER, from his own and VOGEL'S observations, showed this to be enormously in error. (See *Publications A. S. P.*, No. 11, page 284.) In considering the motion of the system of *Algol*, no account is taken of the important investigations of VOGEL and CHANDLER. (See *Astronomische Nachrichten*, No. 2947 and *Astronomical Journal*, Nos. 225 and 226.) Such statements as the following speak sufficiently for themselves. Thus, of $\gamma$ *Cassiopeæ*, "It contains some incandescent hydrogen: it has been burning more than 2,000 years and the fire seems to be as fierce as ever." Of the great nebula in *Andromedæ*, "The spectral analysis indicated that this nebula is entirely gaseous." Etc.

The book is illustrated by nearly 150 cuts, most of which, however, are merely diagrams of double stars.

The book might have been materially improved by extending the account of shooting stars, comets and the planets, and by including also an account of the Sun and Moon. As it is, it contains much that will be of value to amateur astronomers who are interested in double stars.

## NOTICES FROM THE LICK OBSERVATORY.

PREPARED BY MEMBERS OF THE STAFF.

### COMET HOLMES.

Comet HOLMES has been an object of extraordinary interest. Its spectrum and its form at discovery were unique (see *Publications A. S. P.*, No. 26, p. 249); and its subsequent changes of form have been remarkable. On November 8 it was very bright, well defined, nearly round, and about 5′.5 in diameter. It grew larger and fainter, until, on November 24, I observed it to be about 20′ in diameter, and to have assumed the ordinary comet form. It continued to diminish in brightness, and Professor HOUGH writes that about the middle of December it had become so faint as to be a difficult object with the 18½-inch refractor, and that the volume diminished, until, on the 14th of January, it appeared like a faint globular nebula, about 2′ of arc in diameter.

Some time between January 14 and 16 the faint nebulous mass changed into what appeared to be a nebulous star of about the 8th magnitude! It was first detected by PALISA of Vienna, and, later the same evening, by HOUGH at Evanston, by WILSON at Northfield, and by BARNARD at LICK Observatory. The stellar nucleus was surrounded by a bright and well defined nebulosity, about 45″ in diameter. Observations on succeeding evenings showed that the nucleus was decreasing in brightness and the nebulous envelope was growing larger and fainter. In February the comet was very diffuse, with a very poorly defined nucleus

In view of the fact that the orbit of the comet does not differ greatly from those of the asteroids, Mr. S. J. CORRIGAN of St. Paul suggested that possibly the origin of the comet could be attributed to the *collision of two asteroids*, but, after a careful investigation, he concluded that no two of the already discovered

asteroids could so collide. He therefore suggests as a hypothesis that the comet had its origin in the collision of two asteroids which were still *undiscovered*.

The most interesting and scholarly paper on this comet which we have seen is from the pen of Professor Boss of Albany, recently published in the *Astronomical Journal*. In the following article will be found copious quotations from that paper. W. W. C.

## Concerning the Orbit of Comet Holmes, and on the Fluctuations in Brightness of that Comet [by Lewis Boss, Director of the Dudley Observatory, Albany, N. Y.].

"Considering the past behavior of this comet it may be thought desirable to keep a watch upon its place for some time to come.

In order to facilitate this purpose, I present herewith the results of a new calculation of its elements. These are based upon normal places derived from observations of November 8 to November 15, inclusive, 31 observations; December 9 to December 16, 16 observations; January 16 to January 21, 20 observations. * * *

ELEMENTS.

Epoch 1892, December 14.5, Gr. M. T.

$$M = 26^\circ\ 18'\ 27''.6$$

$$\left.\begin{aligned} \pi &= 345\ \ 53\ \ 28.8 \\ \omega &= 14\ \ 12\ \ 14.9 \\ \Omega &= 331\ \ 41\ \ 14.0 \\ i &= 20\ \ 47\ \ 16.5 \end{aligned}\right\} 1892.0$$

$$\phi = 24\ \ 11\ \ 52.4$$

$$\mu = 513''.9093$$

$$\log.\ a = 0.5594134$$

$$T = 1892,\ \text{June}\ 13.21138$$

$$\log.\ q = 0.3303468$$

Period 2521.85 days.

The next perihelion passage is therefore due about May 10, 1899, and under rather less favorable relations than those which theoretically existed for the opposition recently passed.

* * * * * *

Taking into account the apparent precision of the observations, together with the satisfactory representation of the totality of observations since discovery, it becomes quite evident that there has been no very great displacement of the nucleus during

the recent outburst. A total angular displacement of 10″ at right angles to the line of vision would have implied an actual displacement of little more than 10,000 miles. To have produced this displacement within five days would have required an alteration of less than one-fourth of one per cent. (0.0025) in the orbital velocity of the comet, which, at the time of the outburst in January, was moving very nearly at right angles to our visual line.

It is difficult to suppose that a collision, of sufficient violence to have produced the great increase of brightness which was observed, would not have produced a displacement of the nucleus that would have been easily measurable.

A similar argument might apply in some degree against the assumption of an explosion, not absolutely symmetrical, on a scale sufficient to disrupt a nucleus composed of solid matter, and to drive the fragments violently apart. Perhaps, in making such an assumption, one might suppose an explosion of comparatively little violence with the scattering of a cloud of dust or the release of imprisoned gases. Both in the days following the outburst in January, and, after discovery, November 6 (previous to which it is probable that an outburst had occurred), the nebulous envelope of the comet was observed to be in a state of rapid apparent expansion. Supposing this to have been due to projectile velocities, mechanically imparted to particles of dust, would imply a violent initial shock; in which case a little reflection would show that it would be necessary to suppose that the disruptive energy must have acted with remarkable and perhaps incredible symmetry in every direction. If it is considered that the increase of brightness may have been due to the ignition and incandescence of uprushing gases, the spectroscope should have made us aware of that fact. Yet it is notable that the spectrum of this comet has not shown even the usual cometary bands, much less the bright lines of incandescent gases.

On the other hand, it is not necessary to suppose that dust particles were driven off from the nucleus by ordinary mechanical agencies alone, nor that uprushing gases would need to become incandescent in order to be visible. The objection to what might be termed the eruptive hypothesis lies in the difficulty of accounting for the occurrence of an eruption at times when we must suppose that the temperature of the comet had been decreasing for a long period. Then, too, the difficulty of accounting for two successive eruptions of nearly equal magnitude must be considered as vastly

greater than that of accounting for only one—if not, indeed, as insuperable. Therefore, while the eruptive hypothesis may be considered not to be entirely outside the pale of permissible speculation, the admission of it seems to be beset with difficulties which make some other plausible explanation worthy of attention.

That the brightness of comets may be due in part to electrical action, of a nature similar to that which produces the terrestrial aurora, seems to me to be a hypothesis that offers fewer objections than any other which has been proposed. It has appeared to me to be extremely probable that the corona of the Sun is also of a nature analogous to that of our aurora. For the existence of auroral manifestations near a celestial body, it may be assumed that surrounding space filled with matter in a finely divided state, and of extreme tenuity, is most favorable. The upper regions of the Earth's atmosphere, in which the aurora is formed, are undoubtedly of this nature. Much evidence exists to prove that the matter which fills the coronal regions about the Sun is also of this description. The evidence to this effect is still more conclusive as to the physical constitution of the envelopes and tails of comets.

That there is an electro-magnetic action between the Sun and the Earth may be regarded as an established fact, which is evidenced by the synchronism of the periods of solar disturbance with those of auroral displays and of the elements of terrestrial magnetism,—with special and much more striking coincidences of this kind on occasions of unusually intense disturbances. It is entirely natural and reasonable to suppose that this form of intercosmical action also obtains between the Sun and other bodies of the solar system. Considering the enormous extent of the nebulous surroundings of comets, together with other facts concerning their physical constitution and the variation of their distances from the Sun, with probable coincident variation in temperature, it seems not unreasonable to suppose that the action of electromagnetic energy from the Sun upon these bodies may be far more intense and persistent than is the case with other bodies of the solar system.

The development of cometary tails may be completely explained through the agency of a supposed form of energy acting from the Sun in a sense contrary to that of gravitation. It is physically possible that this energy may be synonymous with electrical repulsion due to similar electrifications. The

electrical-repulsion hypothesis to account for the development of the tails of comets was suggested by OLBERS, and has found favor with many special students of this subject. There is a mass of carefully collected mathematical and physical evidence in support of this view, which has already been placed on record in the works of ZÖLLNER, BREDICHIN and others, and no objections or counter-evidence of weight have been presented.

According to the electrical-repulsion hypothesis the molecules of matter composing the nebulous envelope are repelled not only by the Sun, but also by the nucleus of the comet. This action of the nucleus was taken into account by BESSEL, in his classical paper upon the tail of HALLEY'S comet, and is a necessary factor in all refined investigations of this kind. In case of any unusual electrical disturbance in a comet, the first effect would be the repulsion by the nucleus of the matter composing the coma, and the latter would expand on all sides. This expansion would take place quite symmetrically, until the molecules acted upon reached a distance from the nucleus where the repulsive action of the Sun became proportionally large in comparison with that of the nucleus. Then the molecules would be driven back to form the tail. This seems to be precisely what took place with the comet of HOLMES subsequent to discovery, and the matter, fresh in mind, does not appear to call for a more detailed exposition at the present time. Furthermore, the more intense the initial electrical disturbance in the central parts of the comet, the greater would be the expansion of the coma before the peculiar action of tail formation would become strikingly manifest; and a mathematical development of the resultant energies brought into action will show that, under the circumstances described, the tail would be extremely broad and diffused in comparison with the tails of other comets produced under less sudden and violent electrical excitation in the nucleus.

Every one who has had much experience in the observation of comets must have been impressed with the belief that after making all due allowances for the varying transparency of the atmosphere on different occasions, the brightness of telescopic comets does materially vary without strict reference to the relations of distance and by no means with regularity. The variations in brightness of the periodic comets, at their successive returns to perihelion, seem to be largely independent of theoretical relations depending upon their relative distances from the Sun and Earth.

There have been notable instances of abnormal temporary variation in brightness of comets, such as that of the relative brightness of the two fragments of BIELA'S comet, the outbursts of Comet 1888 I (SAWERTHAL) and others. The hypothesis that a part of the light of comets comes from electrical excitation in the nebulous envelopes seems to afford the readiest and most reasonable explanation for these variations of brightness,—the only apparent drawback being that the adoption of this hypothesis might call for a reason why the abnormal variations in the brightness of comets are not more frequent and decided. In all probability the visibility of comets is largely, if not chiefly, due to reflected sunlight, which would give a constant element of brightness that would serve to render the abnormal changes less striking.

The presence of bright bands in the spectra of comets implies incandescence of the matter composing them. Considering the tenuity of the nebulous envelopes of comets, in connection with their volume and the minuteness of the nuclei, and taking into account the probable low temperature of space, it is quite certain that this incandescence is not due to heat in its ordinary form (*i. e.*, from non-electrical sources of heat), and it seems to be impossible to account for it otherwise than as a manifestation of some form of electrical action. This, at least, would seem to be the case with by far the greatest number of comets, excepting only the few that approach the Sun so nearly as to be subjected to a solar radiation sufficient to produce incandescence.

Finally, it may be asserted that the physical appearance of comets is not opposed to this hypothesis of auroral origin for a part of the light, but that, on the contrary, it is quite favorable to that hypothesis. At the distances from which comets are viewed, the form and pulsations of individual streamers should be entirely invisible, as would be, under like circumstances, the details of the terrestrial aurora. All it would be necessary to assume is that this auroral action is more uniform in the surroundings of comets than those of the Earth.

Whatever may be the cause of the fluctuations in the brightness of the comet of HOLMES, it may be considered desirable to keep a watch upon its place for some time after it shall have become too faint (perhaps temporarily) for observation. To aid in maintaining such watch the subjoined Ephemeris has been prepared by my assistants, Messrs. LAY and BENTON, who have also assisted in the computations for the Elements:

EPHEMERIS FOR GREENWICH–MIDNIGHT.

| 1893. | App. α. h. | m. | s. | App. δ. ° | ′ | ″ | log. Δ |
|---|---|---|---|---|---|---|---|
| April 3.5 | 3 | 28 | 10.5 | +36 | 17 | 36 | 0.54929 |
| 7.5 | 3 | 35 | 33.9 | 36 | 27 | 58 | 0.55565 |
| 11.5 | 3 | 42 | 59.5 | 36 | 37 | 55 | 0.56174 |
| 15.5 | 3 | 50 | 26.7 | 36 | 47 | 25 | 0.56757 |
| 19.5 | 3 | 57 | 55.5 | 36 | 56 | 24 | 0.57314 |
| 23.5 | 4 | 5 | 25.4 | +37 | 4 | 51 | 0.57846 |

(Reprinted from the *Astronomical Journal*, No. 292.)

## THE SPECTRUM OF HOLMES' COMET.

The nature of the spectrum of Comet HOLMES has an important bearing upon the question of the origin of that strange object, and I wish to present in detail my reasons for saying with confidence that "underlying the continuous spectrum there is certainly a trace of the green band."

On November 8 and 9, when the most condensed portions of the comet were in the slit, there was seen to be a very slight maximum of light at about λ 515, but it was so slight that the micrometer wire could not be set on it with accuracy. But when the bright parts were thrown out of the slit and the diffuse eastern edge brought in, the contrast between the continuous spectrum and the maximum spoken of above was unmistakable. On November 9 Mr. TOWNLEY assisted me. He had never seen a comet spectrum before, and had no practical knowledge of where the usual cometary bands lie. I requested him to examine the continuous spectrum (of the eastern edge of the comet) from one end to the other; and if he saw any region surely brighter than the regions just above and below, to set the very heavy wire of the micrometer upon it. He did so almost instantly. I then narrowed the slit, threw in the magnesium comparison spark ($b_1$–$b_4$) and noted the position of the wire. Twice more I asked him to set the wire on the maximum, and I compared his settings as before with the magnesium lines. Without any knowledge on his part of where the green band usually falls, or of how his settings compared with the magnesium lines, *his three settings all fell between λ 516 and λ 514.* We were both confident, also, that the maximum was more sharply defined on the red side than on the violet.

I examined the spectrum on November 24, at which time the

comet had become much more diffuse. All parts of the comet gave a continuous spectrum and a trace of the green band, wave length about 516. As before, the band was most noticeable in the spectrum of the fainter regions of the comet. W. W. C.

## THE NEW DUDLEY OBSERVATORY AT ALBANY, NEW YORK.

Letters received from Professor BOSS, the Director of the DUDLEY Observatory, and an excellent press-telegram in the New York *Tribune* of September 24, 1892, give some account of the new DUDLEY Observatory buildings and equipment The accompanying cut is from the *Tribune* article.

The DUDLEY Observatory was originally founded in 1857, by gifts from citizens of Albany. $105,000 were given by the widow of CHARLES DUDLEY of Albany and $80,000 by other persons. The observatory was built under the direction of Dr. B. A. GOULD. Difficulties with the Trustees prevented the first Director from carrying out the plans at Albany which he afterwards adopted for his survey of the Southern Sky at Cordoba. (See *Publications A. S. P.*, Vol. IV, page 25.) Dr. GOULD was succeeded by Professors BRÜNNOW and MITCHELL, and finally by Professor HOUGH, now of the DEARBORN Observatory at Evanston, Illinois. Two volumes of observations, etc., were published by the observatory during the administrations of these gentlemen. Professor BOSS was appointed to be Director in 1876. The income of the observatory was very small, but a special fund of $2700 was subscribed to provide for paying computers and copyists, and with this small sum Professor BOSS undertook to observe one of the zones of the *Astronomische Gesellschaft* containing 8243 stars of the 9th–10th magnitude or brighter lying between 1° and 5° of North Declination. The observations were made during the years 1878-1882, the computations practically finished in 1884, and the final catalogue in 1887. This very important work is a model for publications of its class. Professor BOSS'S chosen work is the determination of fundamental places of standard stars. For this purpose it is above all necessary to have a suitable meridian-circle mounted in a site free from disturbances by railway trains, etc., etc. The N. Y. Central R. R. tracks are very near to the old observatory, and it was determined (in 1891) to exchange the former site for a new one which should be free from this and other objections. This exchange was effected, and a sum of $15,000 gained in this way: Miss CATHERINE

THE NEW DUDLEY OBSERVATORY.

BRUCE of New York City gave an endowment-fund of $25,000; (Miss BRUCE, a member of this Society, had already given $50,000 to provide the photographic telescope for Harvard College Observatory). Other subscriptions amounting to nearly $19,000 have been received, mostly from the children of Messrs. OLCOTT and PRUYN, once Trustees of the original observatory. The new site is said to be entirely satisfactory. The plans for the buildings have been prepared by Professor Boss himself. A new 12-inch equatorial has been provided; and the former meridian-circle will be improved in several respects, and mounted and housed in the best manner. The rough cut herewith shows the general appearance of the observatory and the observers' house. The building for the meridian-circle is behind these structures, and is hidden by them. To complete the equipment, some $6,000 more are required, which will, no doubt, be provided in due time. The new DUDLEY Observatory has been built to do a definite class of work entirely on the plans of the astronomer who has the work to do. It is hoped to be ready for work in the autumn of 1893. Even this inadequate account of the new institution will, no doubt, be welcome to those who know how much is to be expected from it. E. S. H.

## PHOTOGRAPHING THE CORONA WITHOUT AN ECLIPSE.

Several years ago Dr. HUGGINS made a series of experiments to determine whether it is possible to photograph the solar corona without an eclipse of the Sun. The difficulties to be overcome do not arise so much from the presence of the intensely brighter photosphere as from the fact that to all appearances the diffused light in our own atmosphere during full sunshine is stronger than the light of the corona. Dr. HUGGINS was hopeful of finding that in some region in the photographic part of the spectrum the light of the corona would exceed that of the sky. If only that part of the spectrum were used to photograph the Sun's surroundings, the contrast between the corona and the sky would permit the coronal outlines to be registered on the negative. By interposing colored glass screens between the lens and sensitive plate different parts of the spectrum were successively employed, and the best results were obtained by using only the blue rays. The images on some of his plates strikingly resembled the corona in form; but it was not certain whether they were coronal or false images due to instrumental defects.

In a recent number of the *Comptes Rendus* M. DESLANDRES of Paris describes some experiments made by him having the same object in view. He employed two prisms which were exactly alike, placing them at a considerable distance apart, with their refracting edges parallel but the base of one turned in a direction opposite that of the base of the other. The sunlight which passed through the first prism was decomposed, and a small portion of the spectrum thus formed was allowed to fall on the second prism. Passing through the prisms and a lens, the image of the Sun and its surroundings was formed on the sensitive plate and photographed. By suitably moving the second prism images of all colors could be formed on the plate. When the ultra-violet portion of the spectrum was used, M. DESLANDRES found that corona[l] forms were photographed; but whether they were truly coronal or of instrumental origin he was unable to say. Professor HALE of Chicago made similar attempts last year, using the same general principles, and arrived at exactly the same results. He is now having constructed an instrument with which to continue the experiments, and he hopes to obtain results of practical value.

Our present limited knowledge of the corona depends upon observations made at eclipses with great haste and inconvenience. The experiments made by Messrs. HUGGINS, DESLANDRES and HALE do not offer much encouragement that the corona can be photographed and studied at our leisure. Successful results in this work would be extremely valuable: not only would our knowledge of the Sun be rapidly extended, but astronomers would largely be relieved from the responsibility of expensive and perilous voyages to observe eclipses. W. W. C.

CLASSIFICATION OF STELLAR SPECTRA.

Prof LOCKYER has communicated to the Royal Society a discussion of 443 photographs of 171 bright stars which have been obtained at Kensington and Westgate-on-Sea during the past two years. The spectra were formed by placing prisms of 7½° and 45°, at different times, in front of the object-glass of a 6-inch refracting telescope. The discussion is based primarily upon the amount of continuous absorption in the violet end of the spectra. The varying thickness of the hydrogen and other lines is also taken into account, and several very interesting facts come out of the classification of the spectra. Thus, stars which show

no remarkable absorption in the violet are characterized by broad hydrogen lines. Stars which show a considerable absorption in the ultra-violet have thinner hydrogen lines, of about the same average thickness as those in the solar spectrum. Stars showing a very considerable amount of continuous absorption in the violet have very thin hydrogen lines. The same arrangement does not hold true for the other lines of the spectra, however, for "there are stars in which the hydrogen lines have the same average thickness, while the remaining lines are almost entirely different." An attempt has been made to arrange the stars with reference to their temperatures.

It will be remembered that a few years ago Prof. LOCKYER published his *Meteoric Hypothesis*, which contends that all celestial bodies are, or have been, swarms of meteorites, the difference between them being due to different stages of condensation. It is his opinion that these results confirm the conclusions previously arrived at from visual observations. Prof. LOCKYER'S hypothesis depends very largely upon assumed wave lengths of lines in the bright-line spectra. Until recently these wave lengths were known only very roughly. The observations of nebular spectra by KEELER and others show pretty definitely that Prof. LOCKYER'S assumptions regarding the principal nebular lines are not tenable. My observations of the bright lines in the WOLF-RAYET stellar spectra (see note respecting γ *Argus* below), show that the wave lengths of the lines are, for the most part, radically different from those assumed by Prof. LOCKYER. W W. C.

## DR. HENRY DRAPER'S PHOTOGRAPHS OF THE MOON.

In these *Publications*, Vols. III, page 374, it was mentioned that it was the intention of Mrs. ANNA PALMER DRAPER to present to the LICK Observatory a selection of copies of the best negatives of the Moon made by Dr. HENRY DRAPER at his observatory at Hastings-on-Hudson in the years 1863-1880 with reflectors of 28 and 15.5 inches (made by himself), and with an 11-inch photogahphic refractor (made by ALVAN CLARK & SONS). The originals of these pictures are deposited in the Columbia College Observatory, New York. Mrs. DRAPER'S kind intention has recently been carried out, and a set of copies has been presented to the observatory. They were made by Mr. MONELL, of the College Observatory, under the direction of Professor REES. The photographs were taken on the following dates. The "age" is approximate only:

| 1863. | Age. | 1873. | Age. |
|---|---|---|---|
| Sept. 2 | 19 days. | July 16 | 22 days. |
| Sept. 3 | 20 days. | Sept. 9 | 18 days. |
| Sept. 3 | 20 days. | Sept. 12 | 21 days. |
| **1864.** | **Age.** | Sept. 13 | 22 days. |
| June 13 | 9 days. | **1874.** | **Age.** |
| June 13 | 9 days. | July 22 | 9 days. |
| Oct. 18 | 17 days. | July 24 | 11 days. |
| **1872.** | **Age.** | **1878.** | **Age.** |
| Sept. 9 | 7 days. | July 14 | 14 days. |

| 1880. | Age. |
|---|---|
| Aug. 29 | 24 days. |
| Aug. 29 | 24 days. |
| Sept. 24 | 20 days. |
| Sept. 30 | 26 days. |

**The grateful thanks of the observatory are returned to Mrs. DRAPER for this important addition to its collections. E. S. H.**

## THE MOTION OF THE SOLAR SYSTEM.

Dr. KEMPF of Potsdam, at Prof. VOGEL'S suggestion, has investigated the value of the recent Potsdam spectroscopic observations, when applied to the problem of the Sun's motion in space. The velocities of 51 bright stars were measured. By giving equal weights to the results for all the stars and solving for the resultant motion of all (which is assumed to be exactly the opposite of the Sun's motion) it was found that most probably the solar system was moving towards that point of the heavens whose co-ordinates are:

$$\text{R. A.} = 206^\circ.1 \pm 12^\circ.0, \qquad \text{Dec.} = +45^\circ.9 \pm 9^\circ.2,$$

with a velocity of 11.61 ± 1.84 English miles per second. But it is known that in certain groups of stars the individual stars have nearly equal velocities and proper motions. Such groups are, in the Potsdam list, $\beta$, $\gamma$, $\delta$, $\epsilon$, $\zeta$ *Orionis*, $\beta$, $\gamma$, $\epsilon$, $\zeta$, $\eta$ *Ursæ Majoris*, and $\alpha$, $\beta$, $\delta$ *Leonis*. By treating each of these groups as if it were a single star, Dr. KEMPF obtained the following as the most probable elements of the solar motion:

$$\text{R. A.} = 159^\circ.7 \pm 20^\circ.2, \quad \text{Dec.} = +50^\circ.0 \pm 14^\circ.3,$$
$$\text{Velocity} = 8.06 \pm 2.02 \text{ English miles.}$$

Previous determinations of the solar motion have all been

based upon proper motions and parallaxes. The half-dozen determinations by STRUVE, STUMPE, BOSS and others all place the direction of motion between the limits

252° and 290° for Right Ascension,
and + 14° and + 51° for Declination.

It will be noticed that the Potsdam results both lie far outside these limits in Right Ascension, and very near the upper limit in Declination.

By assuming the direction determined by L. STRUVE,

R. A. = 266°.7, Dec. = + 31°.0,

and solving for the velocity as the only unknown quantity, Dr. KEMPF obtained

Velocity = 7.64 ± 1.84 English miles.

As a result of the investigation Prof. VOGEL concludes that the data of observation are not extensive enough to furnish with any certainty the co-ordinates of the point towards which the solar system is moving; but that the observations, few as they are, determine the velocity of the motion more satisfactorily than do the earlier investigations which were based upon the apparent proper motions and the very uncertain distances of the stars.

W. W. C.

## UNIVERSAL TIME.

The bill declaring the legal time for Germany to be that of the 15th meridian east of Greenwich passed the third reading on February 16. It is to come into force on April 1. In a letter addressed to the Astronomer Royal, it is stated by Dr. SCHRAM that a similar bill has been laid before the Austrian Parliament, and it is hoped that the change will be made simultaneously with Germany. The draft of the Austrian bill provides—

I. That the legal time in Austria is the mean solar time of the meridian 15° east of Greenwich. The same is to replace on April 1, 1893, the present local times for legal, civil, and all other purposes.

II. The Government is authorized to make the changes in the school and industrial hours, which will become necessary in consequence of the adoption of the above.—From *The Observatory*, March, 1893.

## THE VISIBLE SPECTRUM OF $\gamma$ *ARGUS.*

I have recently undertaken to determine as accurately as possible the positions of the bright lines in the spectra of some of the WOLF-RAYET stars. Fifty stars of this type are now known, of which $\gamma$ *Argus*, of the 3d magnitude, is the only bright one. When this star is on the meridian of Mt. Hamilton its altitude is less than 6°, and can be observed with the great telescope only a few minutes each evening. Nevertheless, I have secured a few observations of its visible spectrum, which, while not as accurate as they would be if the star were advantageously situated, may be of interest. The following wave lengths are preliminary only, since I have not at present the accurate wave lengths of the comparison lines employed. The continuous spectrum is visible from about B to K, being particularly strong in the blue and violet:

BRIGHT LINES IN THE VISIBLE SPECTRUM OF $\gamma$ *ARGUS.*

| Line. | 1893, Feb. 15 | Feb. 17 | Feb. 18 | Feb. 19 | Feb. 20 | Feb. 22 | Feb. 23 | Feb. 27 | Mar. 27 | Mean. |
|---|---|---|---|---|---|---|---|---|---|---|
| | 670 | | | | 6727 | | 6726 | | | 6726 |
| C | 6563 | | | | 6564 | | 6566 | | | 6564 |
| $D_3$ | 5876 | 5874 | 5873 | | | | | 5875 | 5875 | 5875 |
| | 5814 | 5814 | 5813 | | | | | 5809 | 5813 | 5813 |
| | 5695 | 5695 | 5694 | | | | | 5693 | 5696 | 5695 |
| | | | | | | | | 5594 | | 5594 |
| | | | | | | | | 5412 | | 5412 |
| | | | | 4691 | 4690 | 4692 | | 4689 | 4689 | 4690 |
| | | | | 4652 | 4651 | 4651 | | 4651 | 4650 | 4651 |
| | | | | | | | 4440 | 4442 | 4442 | 4441 |

$\lambda$ 6726 and $\lambda$ 5594 are rather broad, faint and poorly defined bands or lines. $\lambda$ 5412 is extremely difficult, and is the same line that is very bright in some of the WOLF-RAYET stars at about $\lambda$ 5415. $\lambda$ 4651 is broad, much brighter than its companion at $\lambda$ 4690, and is strongly suspected to be double, with components near wave lengths 4644 and 4659. The relative intensities of the lines will be shown later in an intensity curve.

A photograph of the spectrum, just obtained, though very much over-exposed, shows many additional bright lines, and also that *the H $\gamma$, H $\delta$ and H lines are dark.* The C line is very bright.

W. W. C.

1893, March 29.

## PHOTOGRAPH OF A BRIGHT METEOR.

ANSONIA, Connecticut, March 18, 1893.

*Secretary of the Astronomical Society of the Pacific.*

DEAR SIR:—I take pleasure in sending herewith a print of a meteor trail which I obtained on January 13 of this year. I was trying to get a photograph of HOLMES' comet to add to some I had already made, and while so engaged was startled by a bright light. On developing the plate I found that an immense meteor had passed directly across the centre of my plate (a 4 x 5). The exposure on the stars was for 33 minutes, and although these are very distinct and show down to 10½ magnitude, the meteor trail, which was of course instantaneous, is very much more intense than any of the stars.

This plate is valuable also as testifying to the extreme faintness of HOLMES' comet on January 13, the exposure of 33 minutes failing to bring it out. Within three days it had altered, as you know, to an 8th magnitude star. The change, therefore, must have taken place after the 13th. Microscopic examination of the meteor trail reveals very remarkable fluctuations of the light of the meteor during its passage across the plate. An enlargement of about seventeen times looks like a row of knots tied in a string. These are undoubtedly due to small pieces breaking off, and also to the revolution of the meteor on its axis.

Yours respectfully,

JOHN E. LEWIS, Member A. S. P.

## LARGE DISCS OF OPTICAL GLASS.

It is reported that MANTOIS of Paris, the celebrated maker of optical glass, is preparing discs thirty inches in diameter to be exhibited at the World's Fair. It is to be hoped that they may be figured and retained in this country. They ought to come to California. The number of observatories provided with powerful telescopes can still be increased without having too many. The science of astronomy is broadening rapidly, new fields of investigation are being opened up, and by reason of the vast amount and great variety of work to be done, no one great telescope would necessarily duplicate the work of another. For this reason great telescopes are not competitors. W. J. HUSSEY.

STANFORD UNIVERSITY, March, 1893.

## NEW PHOTOGRAPHIC SPECTROSCOPE FOR THE 36-INCH EQUATORIAL.

The present star-spectroscope of the 36-inch equatorial was designed for visual observations only. The work of Messrs. KEELER and CAMPBELL has shown it to be entirely satisfactory in this kind of observation. Mr. CAMPBELL's photographic spectroscopy has been done so far by simply replacing its eye-piece by a small camera. But the construction of the instrument does not give enough stability to allow of long-continued photographic exposures. In such cases flexure must be provided against by setting the whole optical train rigidly within a trussed beam of some sort, either as designed by Prof. VOGEL at Potsdam, or by Professors HALE and KEELER at Chicago and Allegheny. Professor CAMPBELL has worked out plans of this sort, and Mr. D. O. MILLS of New York, a member of this Society, has generously provided the necessary money to carry out the plans. The instrument will be built by Mr. BRASHEAR, and it is expected to have it at work during the present summer.

E. S. H.

## VEGETATION OF THE SUMMIT OF MT. HAMILTON.

Prof. EDWARD LEE GREENE has written a paper on the vegetation of the summit of Mt. Hamilton, based on a botanical survey made by him in 1891, and on the examination of collections of dried plants made here by C. T. BLAKE, Esq., and by Miss MILDRED HOLDEN. A list of 212 species is given in the paper, with descriptions of the new ones. The article is printed in Vol. I, No. 4 of the new journal, *Erythea*, edited by the members of the Department of Botany of the University of California.

E. S. H.

## CHANGES IN *NOVA AURIGÆ*.

The *Nova* was observed for brightness in the 36-inch telescope and 4-inch finder on March 25. It was estimated to be 0.2 magnitude brighter than in November, and about 0.5 magnitude brighter than in August. The nebulosity has increased to a remarkable degree since August. Two wholly inexperienced observers were called in to state which of the half-dozen stars in the field was nebulous. They selected the *Nova* almost instantly, though it was only a few degrees from the Moon.

W. W. C.

## AWARD OF THE ACTON PRIZE TO MISS AGNES CLERKE.

Once in seven years the ACTON prize of £100 is awarded to that person whose scientific writings have been most serviceable to the cause of Natural Religion. The last prize was adjudged to Professor G. STOKES of Cambridge University, late President of the Royal Society of London. This year the recipient is Miss AGNES CLERKE, the author of the "History of Astronomy in the XIX Century," of the "System of the Stars,"* of the "Studies in HOMER," etc. The justice of the award is evident; and it is especially noteworthy that Miss CLERKE succeeds the distinguished physicist, Sir G. STOKES. E. S. H.

## FOREST-FIRE NEAR MOUNT HAMILTON, AUGUST, 1891.

After the termination of the forest fires spoken of in these *Publications*, Volume III, page 292, other great fires broke out on Mount Ysabel, about two miles directly east of the observatory. A number of excellent photographs of this fire were taken by Professor CAMPBELL. One of these is reproduced in the frontispiece of the present number from a block kindly furnished by the editor of the *Californian Illustrated Magazine*. E. S. H.

## DISCOVERY OF ASTEROIDS.

The application of photography to the discovery of asteroids, for which Dr. WOLF of Heidelberg recently received the medal of the French Academy, is rapidly extending the list of these objects. About twenty-five have been discovered since January 1, and by only two observers, WOLF and CHARLOIS (of Nice).

W. W. C.

## BRIGHT METEOR, APRIL 14, 1893.

While in the north dome, showing visitors the *Orion* Nebula, a very bright meteor passed across the slit at $8^h$ $23^m$ P. S. T., in a S. E. direction through *Auriga*. It was much brighter than a first magnitude star, and left a train of fire which was visible for several seconds. C. D. P.

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* See *Publications A. S. P.*, Vol. III, page 180.

### Honorary Degree Conferred upon Professor Barnard.

The honorary degree of Doctor of Science was conferred upon Professor BARNARD by the VANDERBILT University of Nashville, Tennessee, in March, 1893. He had previously received (1889) the honorary degree of M. A. from the University of the Pacific, San José. E. S. H.

### Graduate-School of Astronomy at Mt. Hamilton, 1893.

The following named persons will be with us during a part or the whole of the Academic year. We shall be obliged to decline to receive any others, on account of a lack of suitable quarters:

S. J. CUNNINGHAM, Sc. D., Professor of Astronomy and Director of the Observatory, Swarthmore College, Pennsylvania . . . . . . *Special.*

WILLIAM J. HUSSEY, B. S., C. E., Assistant Professor of Astronomy, STANFORD University, California . . . . . . . . . . . . . . *Special.*

A. O. LEUSCHNER,* B. A., Instructor of Astronomy in the University of California, Berkeley . . . . . . . . . . . . . . . . . . . *Cand. Phil.*

HENRY S. PRITCHETT, M. A., Professor of Astronomy and Director of the Observatory, Washington University, St. Louis, Missouri . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Special.*

HERMAN D. STEARNS, B. A., Instructor in Physics in the STANFORD University, California . . . . . . . . . . . . . . . . . . . . . *Special.*

SIDNEY D. TOWNLEY, B. S., M. S., HEARST Fellow in Astronomy . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . *Cand. Phil.*

E. S. H.

### Alphabetical Indexes to Special Libraries.

Theoretically, the proper way to look upon a special scientific library is to regard it as a single book; and to prepare a single index within which all information contained in the entire library is referred to. This has been done for several American libraries (notably in that of the Surgeon-General's office in Washington—where the index so far as printed takes XII large quartos, and refers to no less than 104,000 books and 159,000 pamphlets). In general such an index cannot be prepared on account of the time and labor involved. Wherever a special collection is distributed by subjects on numbered shelves or in numbered cases or drawers, it is exceedingly convenient to have a brief finding-index, alphabetically arranged. And this is true whether the

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* Continuing his work at Berkeley.

library is a small one of a few hundred books, or a large one of many thousands. Such an index has been prepared for use with the LICK Observatory Library, and is printed here because it may be useful to some of our members, and in the arrangement of the Library of the Society. E. S. H.

ALPHABETICAL FINDING-INDEX OF ASTRONOMY.

Aberration.
Asteroids. (Ephemerides of)
" (In general)
Astronomical Bibliography.
" Biography.
" Constants.
" Instruments. (Descriptions)
" (Price-lists)
" " (Theory of)
" Tables.
Astronomy. (History of)
" (Practical)
" (Spherical)
" (Theoretical)
Auroras.
Bibliography.
Binary Stars. (In general)
" " (Orbits of)
Biography.
Book Catalogues.
California. (Statistics of)
Catalogues of Books.
" Colleges.
" Instruments.
" Stars.
Charts of Stars.
" " Harbors. (*See* Geography)
Chemistry.
Chronology.
Clusters of Stars. (Drawings of)
" " (Photographs of)
College Catalogues.
Colored Stars.
Comets. (Drawings of)
" (In general)
" (Orbits of)
" (Photographs of)
" (Spectra of)
Constants of Astronomy.
Construction of the Heavens.
Cosmology.
Description of Instruments.
" Observatories.
Double Stars.
Drawings of Comets.
" Moon.
" Nebulæ.
" Planets.
" Star-Clusters.
" Sun (and Spots)
Earthquakes.
Eclipses of the Moon.
" " Sun.
Electricity.
Ephemerides of Asteroids.
" Planets.
" Satellites.
" Stars.
" Sun.
Fixed Stars. (*See* Stars)
Geodesy.
Geographical Positions.
" Latitudes and Longitudes.
" Maps.
Geography.
Geology.
Gravity (and Variations of).
Heat.
History of Astronomy.
" LICK Observatory.
" Mathematics.
" Physics.
Instruments. (Description of)
" (Price-lists of)
" (Theory of)
Latitudes.
LICK Observatory. (History of)
Logarithmic Tables.
Longitudes.
Lunar. (*See* Moon)

## The New Mounting for the Naval Observatory Telescope.

The new mounting for the 26-inch telescope of the Naval Observatory at Washington has recently been completed by Warner & Swasey of Cleveland, Ohio. The old mounting was built no longer ago than 1870, at a cost of $20,000, by Alvan Clark & Sons, but such a revolution has been wrought in appliances and mechanism for handling large telescopes since then, that it was necessary to construct the mounting entirely anew in order to have the telescope in keeping with the other instruments in what is to be the finest national observatory in the world.

The new mounting will weigh thirty tons, about two-thirds of which comes from the cast-iron rectangular supporting pier, in which is built the great clock for driving the telescope in either stellar, solar or lunar time.

The tube is of sheet steel, 38 feet long, 26 inches in diameter at the object glass, 31 at the center and 24 at the point where the eye-piece is placed. The sheets vary in thickness from one-tenth to one-twelfth of an inch, and have been carefully tested, with a view to bearing all the strain put upon them and maintaining a perfect tube. There is no ornamentation, by polishing or otherwise, except plain black paint. The weight of the tube is 2,000 pounds.

The telescope is equipped for photographic and spectroscopic work and is very complete in all its appliances. One observer will be able to handle the great instrument easily and quickly. The difficulty met in observing a star when it is low in the

heavens, and the eye-piece is brought high above the floor, is overcome by raising the floor by hydraulic rams on the principle employed at the LICK Observatory and first proposed by Sir HOWARD GRUBB. The observer touches an electric button in a key-board by his side and raises or lowers the floor at will.

The clock is wound automatically by electricity. When the weights reach a certain point they switch on an electric current, which is cut off again when they are wound up. The ease in handling the telescope is increased by the devices to reduce friction. The shaft of the polar axis rests on hardened steel ball bearings resembling those in fine bicycles, and at the top it works on a necklace of anti-friction rolls.—Adapted from a paragraph in the *Scientific American*, March 25, 1893.

## TOTAL SOLAR ECLIPSE OF APRIL, 1893.

The following telegram was sent to the press on April 18:

LICK OBSERVATORY, April 18, 1893.

"A cipher telegram just received from Prof. SCHAEBERLE, in Chile, informs us that the LICK Observatory expedition to observe the Total Solar Eclipse has been successful in every respect. The mechanical theory of the solar corona proposed by Prof. SCHAEBERLE has been verified. A drawing of the corona of April 16 was published by him in January last as a prediction of what this corona was to be like; and I understand his telegram to mean that the picture made by him months ago was a true representation of the actual corona visible at the eclipse. This is an important verification of a very far-reaching theory. The extension of the solar corona was first photographed at the California eclipse of January 1, 1889, and was fully described in the LICK Observatory report of that eclipse.

Its existence was doubted by various European astronomers, and the cloudy weather did not allow it to be plainly photographed at the eclipse of December, 1889. Now, however, Prof. SCHAEBERLE telegraphs that it has been again successfully photographed at his station high up in the mountains.

Fifty photographs have been secured by Prof. SCHAEBERLE and his assistants, using three different telescopes. One of these instruments gives an image of the Sun over four inches in diameter, and the corona covers a plate 18 by 22 inches. The whole programme was satisfactorily carried out.

It is only proper to add that the expenses of the LICK Observatory expedition were generously provided for by a gift from Mrs. Senator HEARST of California, to whom science owes a new debt."

EDWARD S. HOLDEN.

## Minutes of the Meeting of the Board of Directors, held in the Rooms of the Society, March 25, 1893, at 7:30 P. M.

Vice-President Molera presided. A quorum was present. The minutes of the last meeting were read and approved.

Baron Albert von Rothschild of Vienna, Austria, was elected a life member. The following members were duly elected:

List of Members Elected March 25, 1893.

| | |
|---|---|
| Allen H. Babcock | Care General Electric Company, 15 First St., S. F., Cal. |
| Miss Frances L. Beans | 489 N. First St., San José, Cal. |
| Mrs. T. Ellard Beans | 489 N. First St., San José, Cal. |
| Ernest A. Cleveland | Vancouver, B. C. |
| Isaac H. Davis | Dorchester, Mass. |
| C. W. Dearborn | Care Oakland Bank of Savings, Oakland, Cal. |
| Prof. James Norris Hart | Maine State College, Orono, Me. |
| Mrs. A. G. Heaton | 1330 Nineteenth St., Washington, D. C. |
| Mrs. M. E. Hutton | 26 Union St., New Brunswick, New Jersey. |
| José Ortiz Monasterio | Instituto Mexico, Esquina Plateros y Empedradillo, City of Mexico, Mexico. |
| R. S. Morrison | Equitable Building, Denver, Colo. |
| Guillermo Puga | National Observatory, Tacubaya, Mexico. |
| Baron Albert von Rothschild* | Vienna, Austria. |

Mr. Molera presented to the Board a communication, stating that a Mexican Section has effected an organization at the National Observatory of Tacubaya, under the provisions of Article XVI of the By-Laws of the Society, with the following local officers: Executive Committee—A. Anguiano (Chairman), Camilo Gonzalez, Francisco Rodriguez Rey, Agustin Aragon.

It was, on motion,

*Resolved*, That the Mexican Section of the Astronomical Society of the Pacific be authorized and duly recognized.

The Secretary was authorized to effect a fire insurance of $2,000 on the property of the Society.

Adjourned.

## Annual Meeting of the Astronomical Society of the Pacific, held in the Lecture-Hall of the California Academy of Sciences, March 25, 1893.

The meeting was called to order by Vice-President Molera. The minutes of the last meeting were approved.

A list of thirteen new members duly elected at the Directors' meeting was read to the meeting.

The following papers were presented:

1. Address by Vice-President E. J. MOLERA.
2. Physical Observations of *Jupiter's* Satellites in Transit, by JOHN TEBBUTT Esq., of Windsor, N. S. W.
3. The Solar Motion, by W. H. S. MONCK, of Dublin.
4. A Summary History of Astronomy in America from 1620 to 1893, by EDWARD S. HOLDEN.
5. Evolution of the Double-Star Systems, by Dr. T. J. J. SEE, of the University of Chicago.
6. The Surface Markings of *Mars* (with an exhibition of lantern-slides), by Professor W. J. HUSSEY, of the STANFORD University.
7. Two new Planispheres, by Professor W. J. HUSSEY.
8. Miscellaneous Observations of *Nova Aurigæ*, by W. W. CAMPBELL, of Mount Hamilton.
9. An Easy Method of Adjusting an Equatorial Telescope, by ROGER SPRAGUE, of Napa.
10. Astronomical Observations made in the year 1892, by T. KÖHL, of Odder, Denmark.

The Committee on Nominations reported a list of names proposed for election as follows: Messrs. ALVORD, CAMPBELL, HOLDEN, HUSSEY, JOHNSTON, MOLERA, PIERSON, SCHAEBERLE, SOULÉ, VOORSANGER, ZIEL.

For Committee on Publication: Messrs. HOLDEN, CAMPBELL, YALE.

Messrs. BURCKHALTER and DENICKE were appointed as tellers. The polls were open from 8:15 to 9 P. M.

After counting the ballots, the tellers announced that the following persons had received a majority of the votes cast, namely: Messrs. ALVORD, CAMPBELL, HOLDEN, HUSSEY, MCCONNELL, MOLERA, PIERSON, SCHAEBERLE, SOULÉ, VON GELDERN, ZIEL.

The Chairman declared these gentlemen duly elected to serve as Directors for the ensuing year.

## REPORT OF THE COMMITTEE ON THE COMET-MEDAL, SUBMITTED MARCH 25, 1893.

This report relates to the Calendar year 1892. The comets of 1892 have been:

Comet *a*; (unexpected comet) discovered by Dr. LEWIS SWIFT of Rochester, New York, on March 6.

Comet *b*; (WINNECKE'S periodic comet) re-discovered by Dr. R. SPITALER of Vienna, on March 18.

Comet *c*; (unexpected comet) discovered by W. F. DENNING Esq. of Bristol, England, on March 18.

Comet *d*; (unexpected comet) discovered by W. R. BROOKS Esq. of Geneva, New York, on August 28.

Comet *e*; (unexpected comet) discovered, by photography, by Prof. E. E. BARNARD of the LICK Observatory, on October 12.

Comet *f*; (unexpected comet) discovered by EDWIN HOLMES Esq. of London, England, on November 6.

Comet *g*; (unexpected comet) discovered by W. R. BROOKS Esq. of Geneva, New York, on November 19.

The Comet-Medal has been duly transmitted to the discoverers of Comets *a, c, d, e, f, g* in accordance with the regulations.

A copy of the Comet-Medal has been presented to the Royal Society of London, in the name of the Astronomical Society of the Pacific, in accordance with a resolution of the Board of Directors, adopted November 26, 1892.

Respectfully submitted,

EDWARD S. HOLDEN,
CHAS. BURCKHALTER,
WILLIAM J. HUSSEY.

The Treasurer read his Annual Report as follow:

ANNUAL STATEMENT OF THE RECEIPTS AND EXPENDITURES OF THE ASTRONOMICAL SOCIETY OF THE PACIFIC FOR THE FISCAL YEAR ENDING MARCH 25, 1893.

GENERAL FUND.

*Receipts.*

| | | |
|---|---|---|
| Cash Balance March 26, 1892 | | 951 20 |
| Received from dues | $2,290 13 | |
| " " sale of publications | 55 39 | |
| " " sale of stationery | 23 20 | |
| " " advertisements | 31 00 | |
| " " Life Membership Fund (interest) | 37 50 | |
| | $2,437 22 | |
| Less transfer to Life Membership Fund | 400 78 | 2,036 44 |
| | | $2,987 64 |

*Expenditures.*

| | | |
|---|---|---|
| For publications | $1,207 60 | |
| For general expenses | 1,186 71 | $2,394 31 |
| Cash Balance March 25, 1893 | | 593 33 |
| | | $2,987 64 |

LIFE MEMBERSHIP FUND.

| | | |
|---|---|---|
| Cash Balance March 26, 1892 | $ 699 83 | |
| Received from General Fund | 400 78 | |
| " " interest | 37 50 | |
| | $1,138 11 | |
| Less interest transferred to General Fund | 37 50 | |
| Cash Balance March 25, 1893 | | $1,100 61 |

DONOHOE COMET-MEDAL FUND.

| | | |
|---|---|---|
| Cash Balance March 26, 1892 | $ 556 19 | |
| Interest | 29 00 | |
| Cash Balance March 25, 1893 | | $ 585 19 |

ALEXANDER MONTGOMERY LIBRARY FUND.

| | | |
|---|---|---|
| Cash Balance March 26, 1892 | $1,633 81 | |
| Interest | 84 70 | |
| | $1,718 51 | |
| Expended for books | 4 50 | |
| Cash Balance March 25, 1893 | | $1,714 01 |

FUNDS.

| | | |
|---|---|---|
| General Fund. Balance on deposit with Grangers Bank | | $ 593 33 |
| Life Membership Fund. Balance on deposit with San Francisco Savings Union | | 1,100 61 |
| Donohoe Comet-Medal Fund. Balance on deposit with San Francisco Savings Union | | 585 19 |
| Alexander Montgomery Library Fund. Balance on deposit with San Francisco Savings Union | $ 877 82 | |
| Alexander Montgomery Library Fund. Balance on deposit with German Savings and Loan Society | 836 19 | 1,714 01 |
| | | $3,993 14 |

F. R. ZIEL, *Treasurer.*

SAN FRANCISCO, March 25, 1893.

The Committee appointed to audit the Treasurer's accounts reported as follows, and the report was, on motion, accepted and adopted, and the Committee discharged:

*To the President and Members of the Astronomical Society of the Pacific:*

GENTLEMEN—Your Committee appointed to audit the accounts of the Treasurer for the fiscal year ending March 25, 1893, have made a careful examination and find same to be correct. (Signed)

J. G. LAVERY,
H. S. HERRICK,
CHAS. G. YALE.

SAN FRANCISCO, March 25, 1893.

During the past year the Society has lost the following members by death: FRAZER ASHHURST, H. D. BACON, A. R. CHURCH, LESTER L. ROBINSON, WILLIAM THAW JR.

The photograph of a meteor trail by Mr. JOHN E. LEWIS, of Ansonia, Conn., was exhibited to the members.

Mr. MOLERA then read his address, at the conclusion of which he presented to the Society twelve beautiful photographs, showing the buildings and instruments of the National Observatory of Tacubaya, Mexico. The Society returned their grateful thanks to him for this gift.

The Chairman then introduced Prof. W. J. HUSSEY of the LELAND STANFORD JR. University, who delivered a lecture on the Planet *Mars*, illustrated by over a hundred slides of the most important drawings made of the markings of the planet from the invention of the telescope to and including the last opposition.

It was, on motion,

*Resolved*, That the thanks of the Society be tendered to the retiring President, Prof. J. M. SCHAEBERLE, for his valuable services on behalf of the Society during the past year, and that he has the best wishes of the members for his complete success in the observation of the solar eclipse of April, 1893.

The meeting then adjourned.

MINUTES OF THE MEETING OF THE DIRECTORS A. S. P., HELD IN THE ROOMS OF THE SOCIETY, MARCH 25, 1893, FROM 10:15 TO 10:45 P. M.

The new Board of Directors was called to order by Mr. PIERSON. A quorum was present. The minutes of the last meeting were approved.

The business in hand being the election of officers for the ensuing year, the following officers were duly elected:

*President:* Mr. E. J. MOLERA.

*First Vice-President:* Prof. FRANK SOULÉ.

*Second Vice-President:* Mr. WM. M. PIERSON.

*Third Vice-President:* Prof. W. J. HUSSEY.

*Secretaries:* Messrs. CAMPBELL and ZIEL.

*Treasurer:* Mr. ZIEL.

The President was authorized to appoint the various Standing Committees of the Directors, and accordingly made the following selections:

*Finance Committee:* Messrs. PIERSON, McCONNELL, ZIEL.

*Library Committee:* Messrs. PIERSON, VON GELDERN, McCONNELL.

The Standing Committees of the Society are:

*Committee on Publication:* Messrs. HOLDEN, CAMPBELL, YALE.

*Committee on the Comet-Medal:* Messrs. HOLDEN (*ex-officio*), SCHAEBERLE, BURCKHALTER (and HUSSEY during SCHAEBERLE's absence).

Adjourned.

## OFFICERS OF THE SOCIETY.



## OFFICERS OF THE CHICAGO SECTION.



## OFFICERS OF THE MEXICAN SECTION.



## NOTICE.

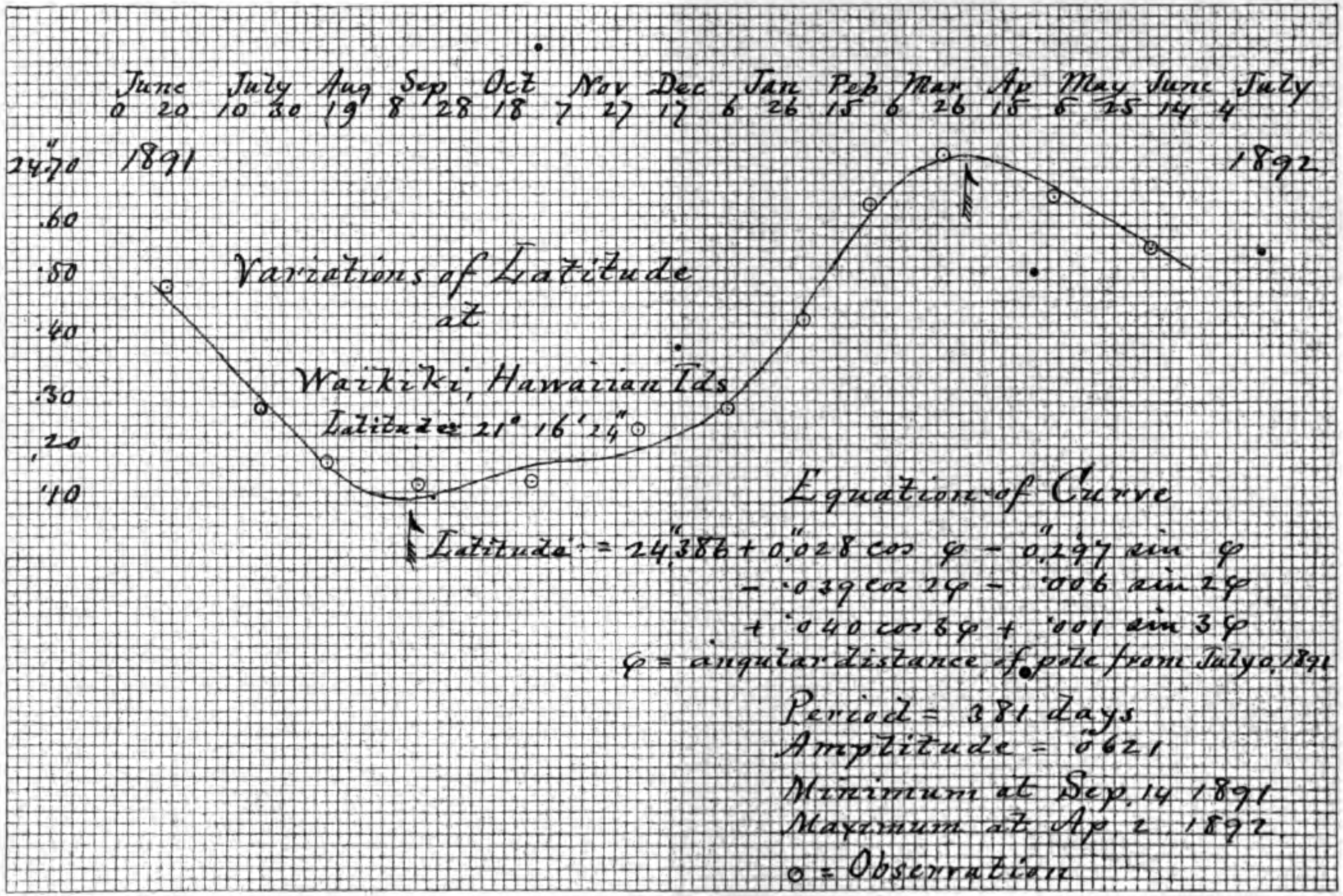
The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book-keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend any or all of the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.


June July Aug Sep Oct Nov Dec Jan Feb Mar Ap May June July
0 20 10 30 19 8 28 18 7 27 17 6 26 15 6 26 15 5 25 14 4
1891
1892
24.70
.60
.50
.40
.30
.20
.10
Variations of Latitude
at
Waikiki, Hawaiian Ids
Latitude = 21° 16′ 24″
Equation of Curve
Latitude = 24″.386 + 0″.028 cos φ − 0″.297 sin φ
− .039 cos 2φ − .006 sin 2φ
+ .040 cos 3φ + .001 sin 3φ
φ = angular distance of pole from July 0, 1891
Period = 381 days
Amplitude = 0″.621
Minimum at Sep. 14 1891
Maximum at Ap 2 1892
○ = Observation

PUBLICATIONS

OF THE

# Astronomical Society of the Pacific.

VOL. V. SAN FRANCISCO, CALIFORNIA, JUNE 10, 1893. NO. 30.

## VARIATIONS OF LATITUDE.

BY E. D. PRESTON.

[Published by permission of the Superintendent of the U. S. Coast and Geodetic Survey.]

In the spring of 1891, the International Geodetic Association undertook observations of latitude in Germany and in the Hawaiian Islands. The question whether the variations of latitude, first brought out by Dr. KÜSTNER, were the result of a real motion of the axis of rotation of the Earth, or whether it was the effect of atmospheric or other conditions, could only be decided by simultaneous observations in widely different longitudes. The Association therefore detailed Dr. MARCUSE of the Berlin Observatory for this work, and asked the coöperation of the U. S. Coast and Geodetic Survey, which service was represented by the writer. The two observers left Washington on the 18th of April, 1891, and arrived at Honolulu on the 8th of May. After observing the Transit of Mercury, on the following day preparations were made for the objective work of the trip, and the observatories were built at Waikiki. During the first days of June the regular astronomical observations began, and they were continued without interruption until the last days of June of the following year. In the American observatory attention was given to other subjects, and during the year nearly one thousand determinations of the relative force of gravity were made. These have not been completely reduced, but will probably be ready for publication, together with other gravity, magnetic and latitude determinations made throughout the islands, in the course of a few months.

In the International Association observations at Waikiki, about 2400 separate determinations of the $\phi$ were made on the

part of the Coast and Geodetic Survey. The stars observed comprised 63 pairs, divided into 8 groups. These were selected by Dr. MARCUSE in Berlin, and were made the subject of careful study. All the usual conditions in the selection of latitude stars, regarding zenith distance, magnitudes, etc., were attained, and, moreover, most of the stars observed were from BRADLEY'S List, so that their proper motions were quite accurately known.

The difference in the latitude of the two observatories was $0''.3$, the American one being the more southern. In addition to this, the mean places adopted in the Coast Survey Office for the stars employed placed this observatory still nearer the equator by $0''.2$, so there is an almost constant difference $0''.5$ in the latitudes as determined by the two parties.

In reducing the observations we have followed Professor ALBRECHT'S treatment of Dr. MARCUSE'S work, except in the manner of distributing the error of closing and other outstanding errors, which were adjusted by the method of least squares.

After the individual values for the latitude were obtained, each group was reduced to its own mean declination system by comparing the mean value of the latitude from any one pair with the mean value deduced from all the pairs. For those nights on which incomplete groups were observed, the mean for the observed pairs was corrected by applying the mean of the quantities necessary to reduce the separate pairs to the mean declination system. On complete nights, of course the mean of all the pairs gave immediately the value sought. The relations which each one of the mean declination systems bore to each other was established by subtracting the mean for each group from the mean of the next following one, and the sum of these differences for the whole series gave the error of closing. If this were the only condition to be satisfied, it should be distributed inversely proportional to the number of pairs forming the group connections. But as during the year, at three different times, the observations were made to include three groups each night instead of two, and moreover, as Group II was re-observed in 1892, as well as Group I, there appear five rigorous conditions to be satisfied, instead of one.

After the least square adjustment the daily means were obtained. These were deduced by combining all the observations on each date for all the groups observed. Each group being reduced to its mean declination system and then corrected by a

quantity depending on the relation between the groups, so as to place them all on the basis of one homogeneous series, weights were applied to each value, and the weighted mean gave the resulting latitude for the day. The weights applied depend on the number of pairs of stars observed. In order to further condense the results, and enable us to represent them graphically on a convenient scale, several successive nights were treated together.

The arrangement was such that each value had about the same weight, and on the average this was equivalent to that of about 40 pairs observed on four nights.

After plotting the results, a period of 415 days was assumed for a complete revolution of the pole, and an equation was deduced depending on the sine of the angular distance of the pole from an assumed position at a given time. This equation being compared with the actual observations, showed that the period adopted was too long, and that the addition of a second periodic term depending on the cosine would improve the agreement and give a curve more closely representing the variations of latitude.

The equation used was:

$$\phi = \phi_0 - 0''.311 \sin nt + 0''037 \cos nt,$$

where $\phi$ is the latitude at the time t counted in days from July 0, 1891.

$\phi_0$ = the mean latitude = $24''.40$.
n = angular daily motion of pole.

The period taken is 378 days, and the amplitude is $0''.62$.

The minimum falls on October 2, 1891, and the following maximum on April 9, 1892. This curve, and the observations from which it was deduced, is shown in the Frontispiece. In order to treat the observations by least squares and discover any terms in the periodic function depending on multiple angles, the values were condensed by taking means of successive groups of four, and the following dates and corresponding latitudes were derived:

| | | | |
|---|---|---|---|
| 1891, June 18.. | 24''.492 | 1892, Jan. 7.. | 24''.272 |
| July 22.. | .265 | Feb. 3.. | .432 |
| Aug. 15.. | .175 | Feb. 27.. | .640 |
| Sep. 17.. | .135 | Mar. 24.. | .728 |
| Oct. 28.. | .138 | May 3.. | .656 |
| Dec. 5.. | .232 | June 7.. | .560 |

These values are represented by the equation:

$$\begin{aligned}\text{Latitude} = 24''.386 &+ 0''.028 \cos \phi - 0''.297 \sin \phi \\ &- .039 \cos 2\phi - .006 \sin 2\phi \\ &+ .040 \cos 3\phi + .001 \sin 3\phi\end{aligned}$$

where the period of 381 days and the values are counted from July 0, 1891. The maximum is at April 2, 1892, and the minimum at September 14, 1891. The amplitude is $0''.621$. $\phi$ is the angular position of the pole.

A bulletin, containing fuller information and further details, is now in course of publication by the U. S. Coast and Geodetic Survey, and copies may be obtained by application to the Superintendent.

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## MEAN MONTHLY AND ANNUAL BAROMETRIC AND THERMOMETRIC READINGS AT MOUNT HAMILTON, 1880–1892.

Following is a table of observations of the barometer and thermometer, more or less complete, taken at the LICK Observatory from September, 1880, up to and including December, 1892, by monthly and yearly means. Observations are wanting during the interval from November, 1885, to June, 1888, inclusive. It should be mentioned that the observations for temperature from September, 1880, to October, 1885, were made with the thermometer in a wooden box at one of the cottages, some seventy feet below the LICK Observatory, and it is probable that the results indicate a higher temperature than those following, which were taken under the usual Signal Service conditions.

As indicated, a portion of the results for temperature is deduced from the mean of the maximum and minimum thermometers, while the remainder is obtained from readings of the dry bulb, taken at 7 A. M., 2 P. M. and 9 P. M. by the formula $\frac{7+2+9+9}{4}$. The barometric observations for 1888, 1889 and 1890 are reduced to the freezing point, 32° F., as indicated. An aneroid barometer was employed before 1888.

No monthly means in this list were accepted which were not obtained from observations on at least 19 days. While the data here presented are not as complete as might be desired, they are the best available. C. D. PERRINE.

LICK OBSERVATORY, May 20, 1893.

| Month. | 1880 | | 1881 | | 1882 | | 1883 | | 1884 | | 1885 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Barometer. | Thermometer F.° | Barometer. | Thermometer F.° | Barometer. | Thermometer F.° | Barometer. | Thermometer F.° | Barometer. | Thermometer F.° | Barometer. | Thermometer F.° |
| January | ...... | .. | 25.721 | 43 | 25.678 | 36 | 25.782 | 41 | 25.719 | 41 | 25.735 | 45 |
| February | ...... | .. | .789 | 44 | .726 | 37 | .687 | 39 | .641 | 40 | .731 | 47 |
| March | ...... | .. | .709 | 46 | ...... | 42 | .703 | 52 | .573 | 40 | .756 | 52 |
| April | ...... | .. | .702 | 57 | ...... | 45 | .687 | 45 | .617 | 42 | .651 | 50 |
| May | ...... | .. | .692 | 60 | ...... | 63 | .691 | 54 | .670 | 55 | .662 | 58 |
| June | ...... | .. | .769 | 64 | ...... | 62 | .743 | 68 | .687 | 56 | .725 | 58 |
| July | ...... | .. | .774 | 70 | .780 | 73 | .784 | 75 | .441 | 68 | ...... | 70 |
| August | ...... | .. | .736 | 68 | .737 | 73 | .786 | 70 | .737 | 69 | .719 | 75 |
| September | ...... | 66 | .719 | 62 | .738 | 68 | .778 | 70 | .670 | 61 | .688 | 67 |
| October | 25.819 | 62 | .737 | 45 | .715 | 51 | .689 | 51 | .685 | 57 | .703 | 67 |
| November | .792 | 49 | .789 | 39 | .732 | 45 | .754 | 50 | .732 | 50 | ...... | .. |
| December | .683 | 43 | .777 | 43 | .691 | 47 | .765 | 46 | .553 | 38 | ...... | .. |
| Mean | 25.765 | 55 | 25.743 | 54 | 25.725 | 53 | 25.737 | 56 | 25.669 | 52 | 25.708 | 59 |

| Month. | 1888 | | 1889 | | 1890 | | 1891 | | 1892 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Barometer. * | Thermometer F. | Barometer. * | Thermometer F. | Barometer. * | Thermometer F | Barometer. | Thermometer F. | Barometer | Thermometer F. |
| January | ...... | .. | 25.744 | 40 | 25.708 | 30.3 | 25.846 | 41.6 | 25.789 | 43.6 |
| February | ...... | .. | .803 | 44 | .732 | 36.0° | .636 | 35.0 | .734 | 41.7 |
| March | ...... | .. | .696 | 45 | .778 | 41.8° | .750 | 41.0 | .735 | 42.6 |
| April | ...... | .. | .773 | 48 | .784 | 41.0 | .743 | 44.2 | .832 | 42.3 |
| May | ...... | .. | .753 | 53 | .759 | 46.5 | .723 | 51.3 | .767 | 52.6 |
| June | ...... | .. | .768 | 67 | .793 | 57.7 | .740 | 55.5 | .771 | 57.3 |
| July | 25.816 | 66 | .788 | 70 | .814 | 69.7 | .792 | 70.9 | .777 | 66.9 |
| August | .801 | 72 | .781 | 70 | .799 | 69.0 | .818 | 71.5 | .880 | 70.8 |
| September | .783 | 69 | .809 | 69° | .778 | 67.4° | .779 | 60.3 | .890 | 61.8 |
| October | .768 | 57 | .799 | 54° | .798 | 58.9° | .821 | 58.7 | .842 | 53.2 |
| November | .740 | 47 | .820 | 50° | .857 | 56.5° | .843 | 51.8 | .832 | 49.7 |
| December | .748 | 44 | .820 | 35 | .809 | 45.7 | .845 | 35.8 | .793 | 39.4 |
| Mean | .776 | 59 | 25.790 | 54 | 25.792 | 51.7 | 25.778 | 51.5 | 25.804 | 51.8 |

° Results obtained from $\frac{\text{max.} + \text{min.}}{2}$. Other thermometer results obtained from dry bulb $\frac{7+2+9+9}{4}$.

* Corrected and reduced to 32° F.

| Year. | Mean Barometer. | Mean Thermometer F. |
|---|---|---|
| 1881 | 25.743 | 54. |
| 1882 | .725 | 53. |
| 1883 | .737 | 56. |
| 1884 | .669 | 52. |
| 1885 | .708 | 59. |
| 1889 | .790 | 54. |
| 1890 | .792 | 51.7 |
| 1891 | .778 | 51.5 |
| 1892 | .804 | 51.8 |
| Mean | 25.750 | 53.7 |

See also Table on page 135.

## RAINFALL AT MOUNT HAMILTON IN THE YEARS 1880–1892.

COMPILED BY C. D. PERRINE.

| Month. | 1880–81 | 1881–82 | 1882–83 | 1883–84 | 1884–85 | 1885–86 | 1886–87 | 1887–88 | 1888–89 | 1889–90 | 1890–91 | 1891–92 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. | in. |
| July | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.00 | 0.00 |
| August | 0.00 | 0.00 | 0.00 | 0.00 | 0.15 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 |
| September | 0.00 | 0.10 | 0.00 | 0.65 | 0.65 | 0.15 | 0.00 | 0.33 | 0.49 | 0.00 | 0.80 | 0.28 |
| October | 0.00 | 0.33 | 6.16 | 2.15 | 3.71 | 0.05 | 0.60 | 0.09 | 0.03 | 4.38 | 0.02 | 0.61 |
| November* | 0.50 | 0.91 | 3.45 | 1.48 | 0.01 | .... | 2.82 | 0.90 | 3.27 | 4.69 | 0.58 | 0.38 |
| December | 9.68 | 9.72 | 1.93 | 2.05 | 33.84 | .... | 2.34 | 11.25 | 4.23 | 13.19 | 5.39 | 9.54 |
| January | 3.51 | 3.55 | 3.10 | 5.60 | 1.99 | .... | 2.83 | 10.04 | 1.04 | 7.93 | 1.38 | 1.97 |
| February | 5.99 | 2.90 | 3.75 | 12.76 | 0.57 | 1.80 | 7.80 | 1.38 | 1.42 | 5.70 | 6.52 | 2.99 |
| March | 1.13 | 5.40 | 8.66 | 16.35 | 1.15 | 5.77 | 1.39 | 3.40 | 6.17 | 4.39 | 4.26 | 5.96 |
| April | 0.98 | 4.70 | 2.66 | 11.96 | 2.08 | 6.79 | 5.75 | 0.68 | 1.92 | 1.79 | 3.08 | 1.90 |
| May | 0.09 | 0.48 | 7.55 | 1.24 | 0.16 | 0.70 | 0.25 | 1.25 | 3.21 | 2.45 | 1.01 | 3.52 |
| June | 0.33 | 1.06 | 0.00 | 3.85 | 0.36 | 0.00 | 0.30 | 0.67 | 0.00 | 0.00 | 0.57 | 0.32 |
| Sums | 22.21 | 29.15 | 37.26 | 58.09 | 44.67 | .... | 24.08 | 30.03 | 21.80 | 44.52 | 23.61 | 27.47 |

* November, 1880.—One shower; amount assumed to be 0.50 inches.

**Mean annual rainfall (11 years), July to July, 32.99 inches.**

**NOTE.—This differs slightly from previous tabulations, but it is believed to be correct.**

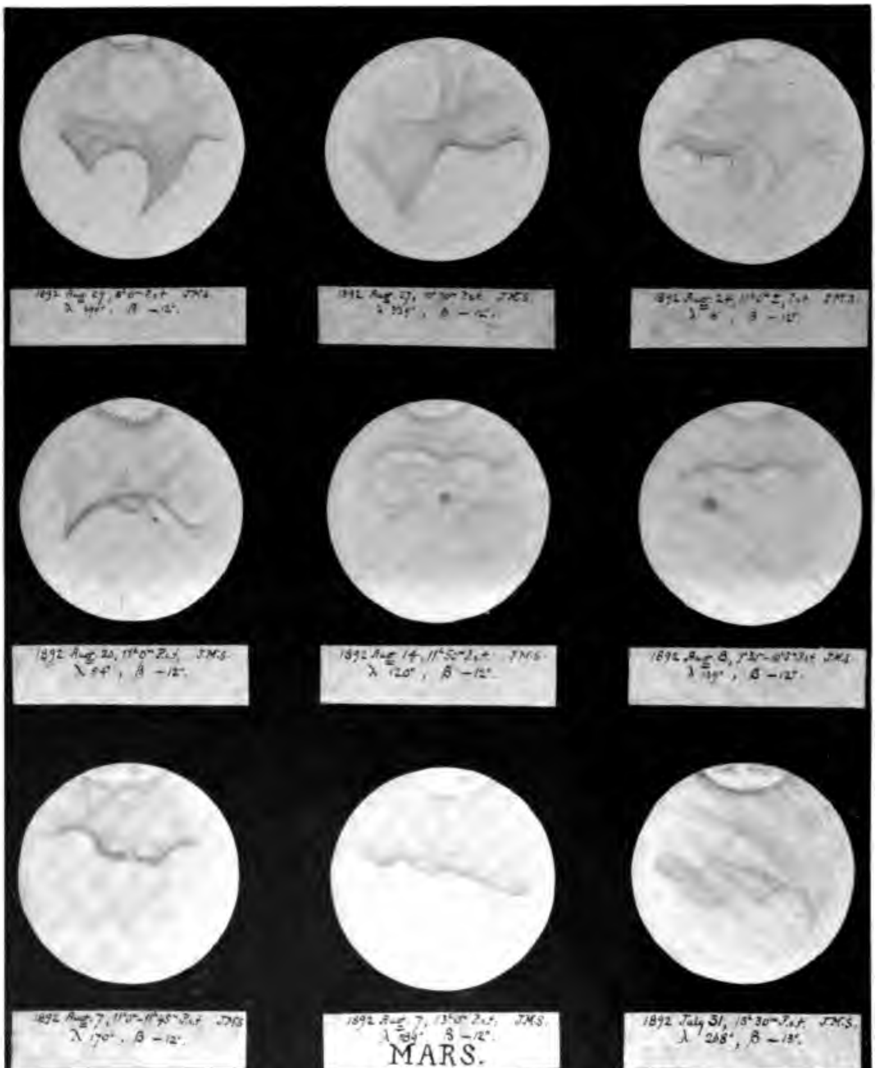


PLATE XI.—DRAWINGS OF MARS, 1892.

By Professor SCHAEBERLE.

# LIST OF EARTHQUAKES IN CALIFORNIA FOR THE YEARS 1891–1892.

COMPILED BY C. D. PERRINE.

The following is a list of the dates and places of occurrence of earthquakes in California (including, also, a number at points outside the State), compiled from observations and reports, both by letter and newspaper, and is a continuation of the list for 1890, printed in No. 16 of these *Publications*, Vol. III, p. 247.

A more complete account for the year 1892 will be published as a bulletin by the U. S. Geological Survey, the list for 1891 having been published in Bulletin No. 95. The times are Pacific standard times.

Roman numerals inclosed in parenthesis indicate the intensity on the ROSSI-FOREL scale.

1891.

January 2, $12^h 00^m 18^s$ P. M. Generally felt throughout the State. Mount Hamilton, San Francisco, Santa Cruz, Salinas, El Verano, Los Gatos, Gilroy, Stockton, Lathrop, Modesto, San José, Petaluma, San Leandro, San Rafael, Boulder Creek, Spanishtown, Merced, Redwood City, Mills College, Oakland, Carson City (Nev.). A third shock of intensity III is reported at Mount Hamilton at $8^h 18^m 21^s$ P. M.

January 12, 1:36 A. M. Berkeley.

January 13, 2:58 P. M. Mount Hamilton. (I to II)

January 31, $2^h 24^m 35\frac{1}{8}^s$ P. M. San Francisco. Artificial earthquake, caused by the explosion of 3,000 pounds of blasting powder. (See *Publ.* A. S. P., Vol. III, p. 132.)

February 15, Downieville. Between 2 and 3 A. M.

February 24, 3:10 A. M. Independence.

April 4, 4:30 A. M. Mount Hamilton.

April 12, $9^h 29^m(?) 41^s$. Mount Hamilton. (II)

April 13, 11:40 P. M. Healdsburg; 11:30 P. M. Visalia.

May 8, 6:10 P. M. Berkeley, San Francisco, Oakland (II); 6:08 P. M., San Rafael.

May 19, Susanville.

May 20, 10 P. M. Mills College.

June 22, 8 to 9 P. M. Pasadena; San Fernando.

June 28, $3^h 02^m 45^s$ A. M. San Francisco, Mount Hamilton, Mayfield.

June 29, $8^h$ $06^m$ $31^s$ A M. Mount Hamilton. (I or II)
July 13, 4:27 P. M. Monterey.
July 17, 1:00 A. M. Hollister.
July 30, 6:00 A. M. Lerdo, Mex.
August 9, 9:41 A. M. Monterey.
September 12, 8:48 P. M. Cedar City, Utah.
September 16, 8:30 P. M. Salem Oregon.
September 21, 4:10 to 5:00 A. M. Port Angeles, Wash.; 4 A:M., Port Townsend, Wash.
September 22, 3:40 A M. Victoria, B. C.
September 23, 1:30 P. M. Healdsburg.
October 2, $7^h$ $19^m$ $55^s$. Mount Hamilton. (II)
October 11, $10^h$ $27^m$ $49^s$ P. M. Felt generally throughout the central portion of the State. San Francisco, Oakland, Suisun, Sacramento, San José, Winters, Fairfield, Spanishtown, Sonoma, Petaluma, Napa, St. Helena, Santa Rosa, San Rafael.
October 13, $11^h$ $00^m$ $30^s$. Mount Hamilton (II), Mills College.
October 14, $4^h$ $33^m$ $23^s$ A. M. San Francisco, Napa, Petaluma, Suisun, San Rafael, Mills College.
October 27, $6^h$ $35^m$ $43^s$. Mount Hamilton. (I or II)
November 8, 8:00 P. M. Ashland, Oregon.
November 29, 3:21 P. M. Seattle, Wash., Snohomish, Bellingham Bay, Port Townsend, Tacoma, Olympia, Wash., Mendocino, Cal.
December 16, $8^h$ $28^m$ $12^s$ A. M. Mount Hamilton. (I)
December 21, $6^h$ $15^m$ $41^s$ P. M. Mount Hamilton. (II)
December 29, $3^h$ $26^m$ $56^s$ A. M. Mount Hamilton. (I to II)

1892.

January 16, 7:30 A. M. Mount Hamilton. Wind blowing 61 miles per hour from N. and N. W., which makes a tremor of the third story of Professor HOLDEN'S house, which would have been called II on ROSSI-FOREL scale.
February 3, 8:30 P. M. Portland, Astoria, Salem (Oregon), Omaha, Neb.
February 5, $6^h$ $27^m$ $42^s$ A. M. Mount Hamilton. (V to VI)
February 23–24. Carson City, Nev. Time uncertain. San Diego.
February 23. Along the Pacific Coast, from Mexico to British Columbia, slight shocks were felt, especially in Oregon and

Washington; 11:15 P. M., Palm Springs, Indio, Beaumont, Pomona, Santa Ana, San Bernardino, Ontario, Visalia, Cal., Yuma (A. T).

February 25, 2:00 A. M. San Diego, Campo, Santa Ana, Ontario.

March 13, 5:25 A. M. Petaluma; 8:35 A. M., Napa.

March 28, 7:30 A. M. Drytown.

April 3, $2^h$ $50^m$ $09^s$ A. M. Mount Hamilton. (III to IV)

April 17, 2:55 P. M. Tacoma, Wash., and Portland, Oregon.

April 19. In the early morning of this day, from about 2:50 to 3:00 occurred the heaviest shock of earthquake that has visited the central part of the State since 1872. The shocks continued at intervals for two or three days following, some of which were almost as severe as the first, A great deal of damage was done, especially in the towns of Vacaville, Dixon, Winters, Woodland and Esparto, probably footing up to nearly a quarter of a million dollars. Following is a list of the towns from which reports of shocks have been received: Vacaville, Dixon, Woodland, Winters, Esparto, Capay, Santa Rosa, Martinez, Fairfield, Napa, Healdsburg, San Rafael, Marcuse, Vallejo, Milton, Placerville, San Francisco, Oakland, Folsom, Grass Valley, Auburn, Chico, Stockton, Nicolaus, Merced, Marysville, Nevada City, San José, Davisville, Elmira, Elk Grove, Galt, Florin, Courtland, Antioch, Benicia, Willows, Colusa, Wheatland, Orland, Biggs, Petaluma, Oroville, Mount Hamilton (IV to V), Suisun, Sacramento, Mare Island, Fresno, Gilroy, Reno (Nev.), Virginia City, (Nev.), Alameda, Carson City (Nev.), Smith Creek, Sutter Creek, Ione, Palermo, Berkeley, Alvarado, San Leandro, Mission San José, Newcastle, Calistoga, St. Helena.

April 20. About 2:00 A. M. Vacaville, Winters, Dixon, Petaluma, Napa, Martinez, Stockton, Elmira, Fairfield, Salem (Oregon), San Francisco, Sacramento, Woodland, Grass Valley, Nevada City, Suisun, Alameda.

April 21. About 9:45 A. M., and 7:15 P. M. The same district was again visited by severe disturbances, in most cases several, and reports come from the following points: San Francisco, Dixon, Winters, Vacaville, Elmira, Benicia, Napa, Petaluma, Sonoma, San Rafael, Davisville, Woodland, Nevada City, Marysville, Grass Valley, Placerville, Chico, Biggs, Healdsburg, Carson City (Nev.), Reno (Nev.), Sacramento, Lodi, Acampo, Fresno, Stockton, Lathrop, Esparto, Martinez,

Madison, Williams, Maxwell, Suisun, Oroville, Auburn, Antioch, Fairfield, Yuba City, Nicolaus, Santa Rosa, Newcastle, St. Helena, Colusa, Merced, Livermore, Haywards, Red Bluff, Willows, Orland, San José, Mount Hamilton, Camptonville, Gold Run, Alameda, Centerville, Spanishtown, Georgetown, Downieville.

April 29, 4:10 P. M. Grass Valley, Marysville, Vacaville, Woodland, Davisville, Petaluma, Winters, Santa Rosa, San Rafael, Napa, Fairfield, Benicia, Stockton, Haywards, San Leandro (7:30 P. M.), San Francisco.

May 11, $9^h\ 48^m\ 32^s$ P. M. Mount Hamilton. (IV)

May 28, 3:15 A. M. Ontario, Santa Ana, San Bernardino.

June 9, 3:40 P. M. Independence.

June 14, 5:20 A. M. Riverside, Santa Ana, Pomona, San Diego, San Bernardino.

June 22. Hollister.

July 9, 9:30 A. M. Explosion of the Giant Powder Works at West Berkeley. Felt generally within a radius of twenty to thirty miles. Reported from Alameda, East Oakland, Oakland, Healdsburg, Sonoma, Sacramento, San Rafael, Duncan's Mills, San Francisco.

July 16, $12^h\ 6^m\ 34^s$ P. M. Mount Hamilton. (III)

July 24, 6:00 A. M. Colton.

July 26, 2:10 A. M. Napa, Petaluma, San Francisco, Mount Hamilton.

August 1 or 2. Mount Hamilton. Record found on plate.

August 2 or 3. Mount Hamilton. " " "

August 5 or 6. Mount Hamilton. " " "

August 8 or 9. Mount Hamilton. " " "

August 18, $8^h\ 8^m\ 27^s$ P. M. Mount Hamilton. (V)

August 24, $13^h\ 22^m\ 14^s$. Mount Hamilton.

August 25. Mount Hamilton.

August 31, 5:00 P. M. Independence.

September 8, 4:45 A. M. Petaluma.

September 23. Oonalaska.

September 25, $2^h\ 10^m\ 43^s$ P. M. Mount Hamilton (III), Mills College, Alameda.

October 26, 7:05 A. M. San Bernardino.

October 30, $12^h\ 17^m\ 12^s$ A. M. Mount Hamilton (III), Independence ($11^h\ 53^m$ A. M.).

November 13, $4^h\ 45^m\ 14^s$ A. M. Mount Hamilton (V), Berkeley, Mills College, Alameda, Petaluma, Gilroy, Hollister, Salinas, Monterey, San Rafael, San Francisco.

PLATE H[1].—DRAWINGS OF MARS, 1892.

By Professor HUSSEY.

# NOTICES FROM THE LICK OBSERVATORY.

PREPARED BY MEMBERS OF THE STAFF.

## PHOTOGRAPH OF THE *ETA* ARGUS NEBULA.

*Knowledge* for April, 1893, contains a superb photograph of the *Eta Argus* nebula, taken by Dr. GILL at the Cape of Good Hope in March, 1892, with an exposure of twelve hours on four days. This note is written for the purpose of advising those of our members interested in such work to procure this number of *Knowledge* (price sixpence, address WITHERBY & Co., 326 High Holborn, London, W. C., England.)

*Knowledge* has printed during the past years a number of such pictures, all equally worthy of notice. But the publishers have sent out the copies *folded* so as to ruin the plates. This number is sent out rolled on a paste-board roller, and, for the first time, it is possible to preserve the plate uninjured. E. S. H.

## PRIZES OFFERED BY THE SMITHSONIAN INSTITUTION.

In October, 1891, THOMAS GEORGE HODGKINS, Esq., made a donation to the Smithsonian Institution, the income from a part of which was to be devoted "to the increase and diffusion of more exact knowledge in regard to the nature and properties of atmospheric air in connection with the welfare of man."

With the intent of furthering the donor's wishes, the Smithsonian Institution now announces the following prizes to be awarded, should satisfactory papers be offered in competition:

1. A prize of $10,000 for a treatise embodying some new and important discovery in regard to the nature or properties of atmospheric air. These properties may be considered in their bearing upon any or all of the sciences—*e. g.*, not only in regard to meteorology, but in connection with hygiene, or with any department whatever of biological or physical knowledge.

2. A prize of $2,000 for the most satisfactory essay upon—
   (*a*) The known properties of atmospheric air considered in their relationships to research in every department of natural science, and the importance of a study of the atmosphere considered in view of these relationships.
   (*b*) The proper direction of future research in connection with the imperfections of our knowledge of atmospheric air, and of the connections of that knowledge with other sciences.

3. A prize of $1,000 for the best popular treatise upon atmospheric air, its properties and relationships (including those to hygiene, physical and mental). This essay need not exceed 20,000 words in length; it should be written in simple language, and be suitable for publication for popular instruction.

4. A medal will be established, under the name of the Hodgkins Medal of the Smithsonian Institution, which will be awarded annually or biennially for important contributions to our knowledge of the nature and properties of atmospheric air, or for practical applications of our existing knowledge of them to the welfare of mankind.

The treatises may be written in English, French, German or Italian, and should be sent to the Secretary of the Smithsonian Institution, Washington, before July 1, 1894, except those in competition for the first prize, the sending of which may be delayed until December 31, 1894.

The papers will be examined, and prizes awarded, by a committee.

Suggestions and recommendations in regard to the most effective application of this fund are invited.

It is probable that special grants of money may be made to specialists engaged in original investigation upon atmospheric air and its properties. Applications for grants of this nature should have the endorsement of some recognized academy of sciences, or other institution of learning, and should be accompanied by evidences of the capacity of the applicant, in the form of at least one memoir already published by him, based upon original investigation.

To prevent misapprehension of the founder's wishes, it is repeated that the discoveries or applications proper to be brought to the consideration of the Committee of Award may be in the

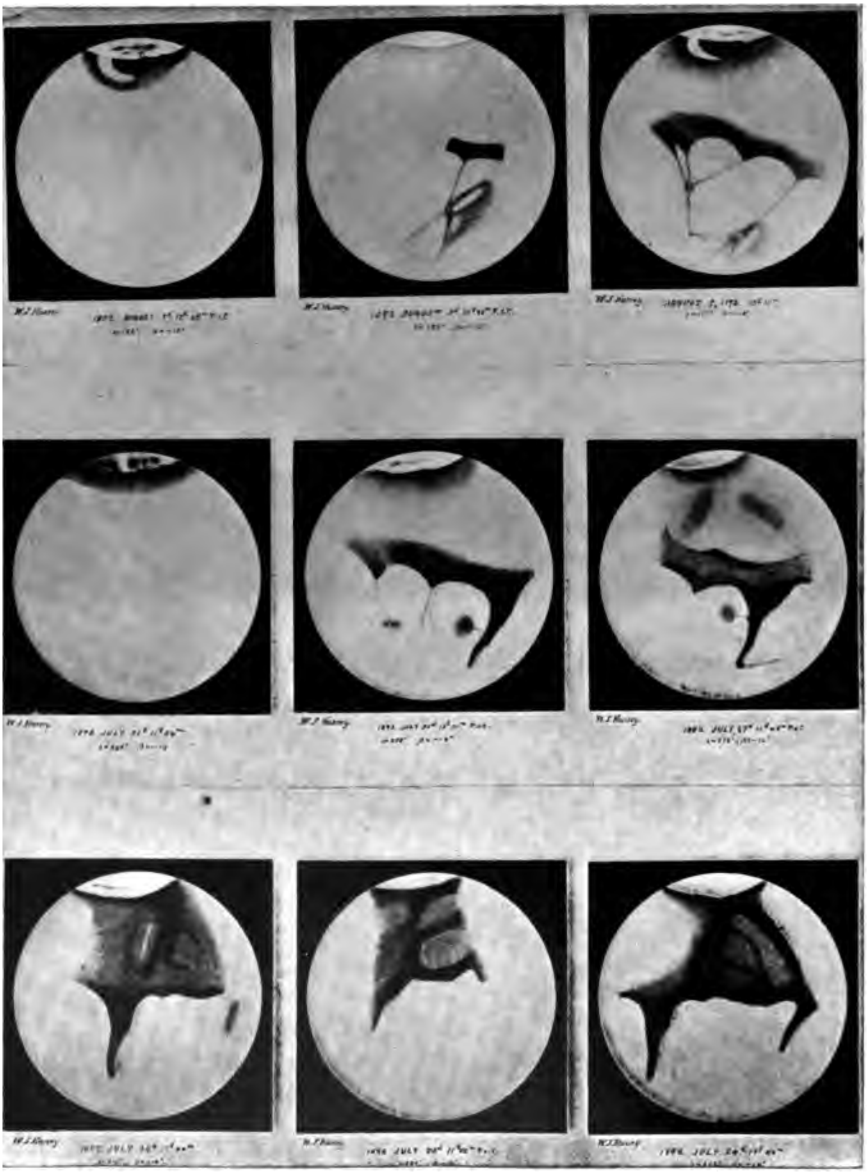

PLATE H².—DRAWINGS OF MARS, 1892.

By Professor HUSSEY.

field of any science or any part without restriction; provided only that they have to do with "the nature and properties of atmospheric air in connection with the welfare of man."

All communications in regard to the Hodgkins Fund should be addressed to S. P. Langley, Secretary of the Smithsonian Institution, Washington.—[Abstract of Dr. LANGLEY'S Circular, as printed in the *Scientific American.*]

### ON PHOTO-MECHANICAL PROCESSES.

Nearly every one, nowadays, is called upon to provide for illustrations of books or papers, or, at least, to criticise illustrations which have been provided by others. Such pictures are very frequently produced by some photo-mechanical process; and it is not only convenient, but essential, to understand the general nature of the process employed. The details can safely be left to the makers of the cuts.

As a guide to the general principles underlying the principal photo-mechanical processes, I have found a paper by Mr. S. R. KOEHLER in the *Technology Quarterly* for October, 1892, (page 161), to be most satisfactory and intelligible. Pretty much everything is there given which the general reader wishes to know. The details must be sought for in special treatises. I take pleasure in advising those concerned about such matters to procure this paper. E. S. H.

### HONORARY DEGREES CONFERRED BY THE UNIVERSITY OF CALIFORNIA UPON PROFESSORS WEINEK AND KEELER.

On Commencement Day of 1893 the University of California conferred the Honorary Degree of *Doctor of Science* upon Professor L. WEINEK, Ph. D., Director of the Observatory of Prague, and upon Professor J. E. KEELER, B. A., Director of the Allegheny Observatory. E. S. H.

### LICK OBSERVATORY DRAWINGS OF *MARS*, 1892.

During the opposition of 1892 *Mars* was assiduously observed with the large telescope by Messrs. HOLDEN, SCHAEBERLE, BARNARD, CAMPBELL and HUSSEY, and with the 12-inch equatorial by Dr. BARNARD. A few drawings of the planet (showing the double canals, etc.) have already been printed in *Astronomy and Astrophysics* for October, 1892.

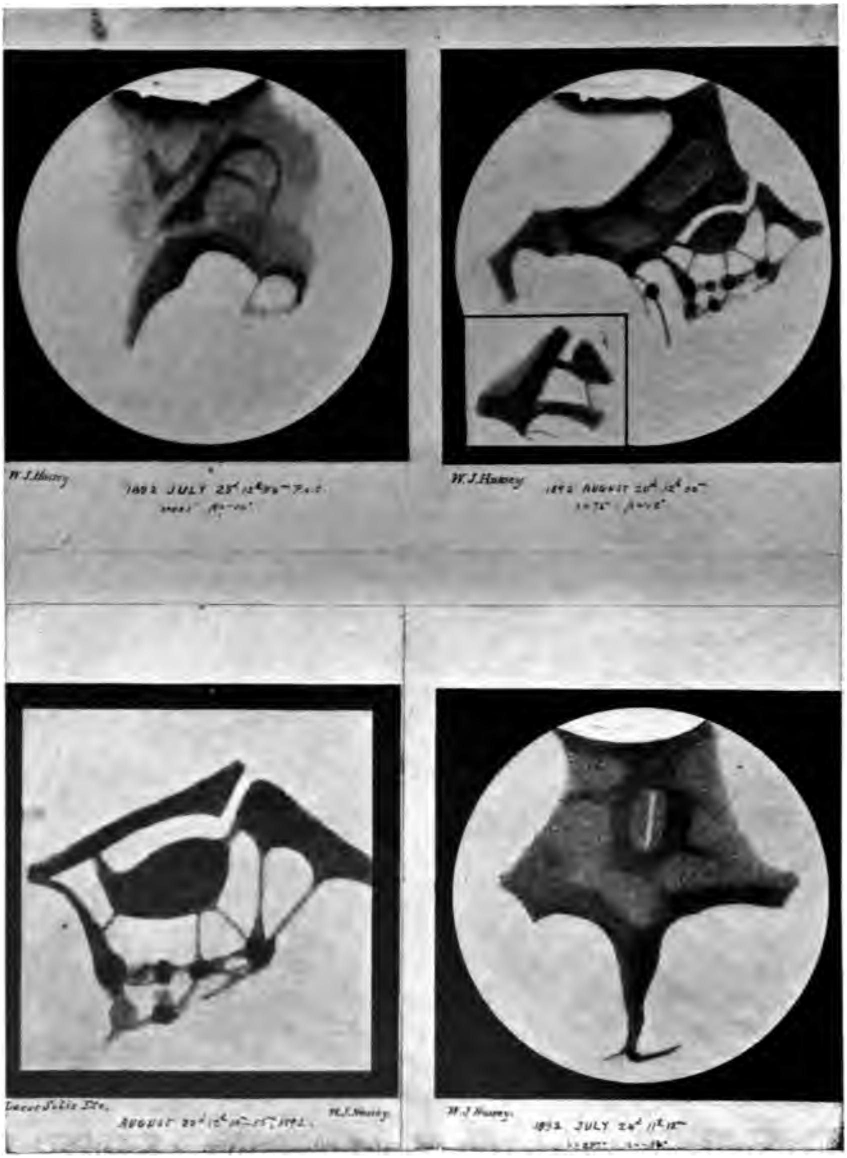


PLATE II[3]. DRAWINGS OF MARS, 1892.

By Professor HUSSEY.

selected from the large collections of the Society; and in particular with copies of the most important of the negatives made at the LICK Observatory, which have been regularly deposited there. It is to be hoped that Messrs. EYRE and SPOTTISWOOD will issue a priced catalogue of the pictures they are prepared to furnish. I remind those of our members who live in California, that I. W. TABER & Co. of San Francisco, have many excellent negatives made here, duplicates of which they will furnish.

E. S. H.

MEAN BAROMETER AND THERMOMETER AT MOUNT HAMILTON BY MONTHS.—1880–1892.

| Month. | Mean Barometer. | Mean Thermometer. |
|---|---|---|
| January . . . . . . . | 25.747 (9) | 40.2° (9) |
| February . . . . . . | .720 (9) | 40.4 (9) |
| March . . . . . . . . | .712 (8) | 44.7 (9) |
| April. . . . . . . . . | .724 (8) | 46.1 (9) |
| May . . . . . . . . . | .715 (8) | 54.8 (9) |
| June . . . . . . . . . | .749 (8) | 60.6 (9) |
| July . . . . . . . . . | .752 (9) | 69.9 (10) |
| August. . . . . . . . | .779 (10) | 70.8 (10) |
| September . . . . . . | .763 (10) | 64.7 (11) |
| October . . . . . . . | .752 (11) | 55.9 (11) |
| November . . . . . . | .789 (10) | 48.8 (10) |
| December . . . . . . | .748 (10) | 41.7 (10) |
| Means. . . . . . . | 25.746 | 53.2 |

C. D. PERRINE.

## Minutes of the Meeting of the Board of Directors, held at the Lick Observatory, June 10, 1893.

Mr. Campbell took the chair, and a quorum was present. The minutes of the last meeting were approved.

The following members were elected:

### List of Members Elected June 10, 1893.*

| | |
|---|---|
| Mrs. Wm. A. Abbé | New Bedford, Mass. |
| J. Lawrence Aspinwall | 71 Broadway, New York, N. Y. |
| N. A. Baldwin | New Haven, Conn. |
| Miss M. M. Barksdale | St. Rose's Academy, Golden Gate Avenue and Steiner Street, S. F., Cal. |
| Wm. C. Belcher | 520 Montgomery Street, S. F., Cal. |
| Edward M. Brewer | 27 Kilby Street, Boston, Mass. |
| Miss Isabella D. Clark | San José, Cal. |
| A. L. Colton* | Lick Observatory, Mt. Hamilton, Cal. |
| Alexander K. Coney | 604 Clay Street, S. F., Cal. |
| Joseph E. Davis | 154 Beacon Street, Boston, Mass. |
| Mrs. Mervyn Donahue | 799 Van Ness Avenue, S. F., Cal. |
| Hon. James F. Houghton | 303 California Street, S. F., Cal. |
| James Lawrence | Groton, Mass. |
| Edgar Mills | Briceland House, Menlo Park, Cal. |
| William Appleton Potter | 39 W. 27th Street, New York, N. Y. |
| Sister Anna Raphael | College of Notre Dame, San José, Cal. |
| Hon. J. B. Reddick | San Andreas, Calaveras County, Cal. |
| Franklin Sidney Rising | 15 First Street, S. F., Cal. |
| Richard Pickering Sellors | Government Observatory, Sydney, N. S. Wales. |
| Judge Charles W. Slack | 1729 Sutter Street, S. F., Cal. |
| Jacob Stout | 135 E. 21st Street, New York, N. Y. |
| Daniel Suter | 235 Kearny Street, S. F., Cal. |
| Aurelius Todd | Eugene, Oregon. |
| Frederic Lamb Wanklyn | 241 Drummond St., Montreal, Canada. |
| Mrs. W. Seward Webb | 680 5th Avenue, New York, N. Y. |

Adjourned.

* A star signifies life membership.

## Minutes of a Special Meeting of the Board of Directors, held in San Francisco, May 25, 1893, at 4 P. M.

President MOLERA presided. A quorum was present. The minutes of the last meeting were approved. On motion the following resolutions were adopted:

*Resolved*, That the vacancy in the Board of Directors be filled by the appointment of Mr. CHARLES BURCKHALTER.

*Resolved*, That the Secretary be instructed to apply for the privilege of holding the November and January meetings of the Society at the CHABOT Observatory, in Oakland.

*Resolved*, That the President and Secretary be authorized to make application to the Mercantile Library Association for an office in the library building, and to effect an arrangement by which the books of the Society can be deposited and cared for in the Mercantile Library, under the same conditions and regulations as formerly (see *Publ. A. S. P.*, Vol. II, page 198).

The Secretary was authorized to make the necessary arrangements for transferring the property and collections of the Society to the new quarters.

Adjourned.

## Minutes of the Meeting of the Astronomical Society of the Pacific, held at the Lick Observatory June 10, 1893.

Mr. W. W. CAMPBELL presided. The minutes of the last meeting, as printed in the *Publications*, were approved.

The Secretary read the names of members duly elected at the meeting of the Directors.

The following papers were presented:

1. Variations in the Geographical Latitude, by E. D. PRESTON, of the United States Coast and Geodetic Survey.
2. Exhibition of Carbon Enlargements of LICK Observatory Moon Negatives on a scale of six feet to the Moon's Diameter, by Baron ALBERT VON ROTHSCHILD, of Vienna.
3. List of Earthquakes in California, 1891-2, compiled by C. D. PERRINE.
4. Exhibition of Blue-prints sent by Professor SCHAEBERLE from South America—representing his eclipse station and three views of the Corona taken on 18 x 22 plates with the 40-foot telescope.
5. Exhibition of Proof-sheets of Heliogravures made by the Imperial Topographical Bureau of the Austrian War Department from drawings by Professor WEINEK and from direct enlargements of the LICK Observatory Moon Negatives.
6. Exhibition of Drawings of *Mars* during the opposition of 1892, by Professors SCHAEBERLE and HUSSEY.

Adjourned.

## OFFICERS OF THE SOCIETY.

E. J. MOLERA (40 California Street, S. F.), . . . . . . . . . *President*
WM M PIERSON (Mills Building, S. F.),
W. J. HUSSEY (Leland Stanford Jr. University, Palo Alto, Cal.), . . *Vice-Presidents*
W. W. CAMPBELL (LICK Observatory), . . . . . . . . . *Secretary*
F. R. ZIEL (410 California Street, S. F.), . . . . . *Secretary and Treasurer*

*Board of Directors*—Messrs. ALVORD, BURCKHALTER, CAMPBELL, HOLDEN, HUSSEY, McCONNELL, MOLERA, PIERSON, SCHAEBERLE, VON GELDERN, ZIEL.

*Finance Committee*—Messrs. PIERSON, McCONNELL, ZIEL.

*Committee on Publication*—Messrs. HOLDEN, CAMPBELL, YALE.

*Library Committee*—Messrs. PIERSON, VON GELDERN, McCONNELL.

*Committee on the Comet-Medal*—Messrs. HOLDEN (*ex-officio*), SCHAEBERLE, BURCKHALTER.

## OFFICERS OF THE CHICAGO SECTION.

*Executive Committee*—RUTHVEN W. PIKE.

## OFFICERS OF THE MEXICAN SECTION.

*Executive Committee*—A. ANGUIANO (Chairman), CAMILO GONZALEZ, FRANCISCO RODRIGUEZ REY, AGUSTIN ARAGON.

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## NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book-keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend any or all of the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

N. Y. ENG-PTG CO

THE MOON.

PHOTOGRAPHED AT THE LICK OBSERVATORY, 1891, OCTOBER 11, 7H., 24M., 29S.-31S. P. S. T.

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# PRELIMINARY NOTE ON THE CORONA OF APRIL 16, 1893, OBSERVED AT MINA BRONCES, CHILE. LONGITUDE, 70° 19′ W; LATITUDE, 28° 27′ S. ALTITUDE, 6600 FEET.

By J. M. SCHAEBERLE.

The accompanying photograph of the corona* is made from the fourth of a series of eight negatives taken with a 40-foot telescope on 18 x 22 inch Seed plates, sensitometer No. 26. The duration of exposures and the approximate times after the beginning of totality are as follows:—

| No. of Negative. | Exposure Time. | Approximate Times after Beginning of Totality. |
|---|---|---|
| | Sec. | Sec. |
| 1 | 0.25 | 2 |
| 2 | 2.00 | 16–18 |
| 3 | 4.00 | 32–36 |
| 4 | 8.00 | 50–58 |
| 5 | 16.00 | 72–78 |
| 6 | 32.00 | 102–134 |
| 7 | 24.00 | 148–172 |
| 8 | .25 | 186 |

In the $32^s$ exposure nearly the whole area of the 18 x 22 plate is covered by the corona. The corona was seen projected on the screen inside of the 40-foot telescope several minutes before

*It is not possible to reproduce the photographs in the present number of the *Publications*.

second contact, and although the last exposure was taken nearly a quarter of a minute after totality, the inner corona and the prominences are conspicuous features of this plate, except where the Sun's limb has burnt out the detail.

The positive copy from the original negative was made by Mr. A. L. COLTON, of the LICK Observatory.

As bearing directly upon the theory of the corona, the photographs taken with five different instruments at the same station show:

First—That, apparently, the matter composing the prominences* and protuberances visible during this eclipse was in orbital motion. In the prominences the matter is distributed with varying density along elliptical arcs symmetrical with reference to the Sun; in many cases these arcs seem to be partially discontinuous; they vary all the way from a normal line to a nearly tangential curve and attain a maximum altitude of about 80,000 miles.

The protuberances visible during this eclipse are shown to be made up of a large number of bright elliptical streams of matter which intersect each other, in projection, at all angles. These streams are so numerous, that, on the smaller scale photographs, this network of lines has the appearance of a continuous surface.

Second—All the remaining visible matter forming the Sun's corona is apparently of a uniform degree of composition and much less dense than the prominences and protuberances, but, as in them, the matter is arranged in the form of (continuous) curved streams of various heights; and each returning stream of the inner corona is plainly visible as a portion of an ellipse whose major axis passes through the Sun's centre, indicating that the matter forming these streams was ejected from the Sun, and is subject to the action of the Sun's gravity. The symmetrical form of these complete arcs (varying again, all the way from a normal line to a nearly tangential stream) indicates that this rare matter suffers practically no resistance to motion due to an atmosphere of the Sun. Structures again, which on the smaller plates appear to follow no law, are, with the aid of the larger plates, shown

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*In this note I consider all photographically visible matter exterior to the Sun's surface as forming a part of the corona, and, for convenience of illustration, the higher and conspicuously individual portion of any protuberance is called a prominence; the former, during this eclipse, attained a mean height of about 20,000 miles; while the latter, as conspicuous structures, rose to a maximum height of four times this amount.

to be due to the superposition of these ellipitical streams. That these arcs are not due to halation caused by the presence of bright prominences follows from the fact that the eccentricity varies as above stated, and from the further fact that no visible change of form took place with reference to the true place of the Sun during the Moon's transit. These visible returning streams are much the most numerous on either side of the Sun's equator and attain a height of 200,000 miles or more.

Third—The outer corona is mainly caused by more nearly radial streams of matter wholly similar in appearance to the curved returning streams of the inner corona. The various trumpet-shaped outlines so plainly visible on the smaller wide-angle plates are seen to be due to the superposition of individual streams, which, in many cases, can be traced from the Moon's outline on the larger plates to a distance of several solar diameters on the smaller negatives.

In no case have I found the actual structure to be concave towards the Sun's centre, and there are only a few cases of very large streamers having apparently greatly inclined initial directions of motion corresponding to very great velocities, the points of eruption being on or near the Sun's limb. The general form of the outer corona is in general agreement with the prediction for a nearly maximum inclination of the Sun's north pole to the line of sight, although the axis of the inner corona cannot be accurately determined, owing to the condensed state of the projections in the polar regions. Marked extensions (nearly radial) projecting far beyond the usual elliptical outline are found in various quadrants, especially in the north polar regions. I wish to call particular attention to a curious structure near the middle of the fourth quadrant; the head of this comet-like object is about four-fifths of a solar diameter from the Sun's surface; it is visible on all my negatives of the outer corona. On the Dallmeyer negatives of the outer corona the Zodiacal light, (equatorial extension of the corona), shows faintly to a distance of at least eight solar diameters from the Sun.

In my "Mechanical Theory" certain results are deduced for a typical corona produced by streamers uniformly distributed in the spot-zones. Now it is evident that this ideal or perfect form will be the exceptional case, and for the reason that the visible solar disturbances in the two spot-zones differ not only from each other, but also because the study of the Sun's visible surface tells us

that the eruptions are not as a rule distributed with exact uniformity in longitude.

The form resulting from an irregular distribution of the streamers can be constructed, provided the longitudes of the various points of eruption and their distances from the origin are known. As the observer will in general have a less latitude than a given stream, it follows that the normally ejected outgoing matter between the Earth and Sun will, in projection, curve away from the equator on the west side of the Sun, and on the east side the curvature will be towards the Sun's equator, for the reason that the outgoing streams in both the northern and southern hemispheres will be on the east side of the normals. Just the opposite condition of things will exist for the outgoing streams on the farther side of the Sun. (See L. O. *Report on the Eclipse of December, 1889*, Plate VIII). For the incoming streams the inclination is reversed. The resulting form of the corona in any particular quadrant will depend upon the relative amount of ejected matter, in the nearer and farther hemispheres of the Sun's surroundings projected in that quadrant. When the observer is exactly in the plane of motion the stream will coincide with normal in projection.

A streamer is evidently made up of a number of nearly parallel streams of matter having presumably many streams with divergent directions of motion. At great distances from the origin such a streamer projected nearly in the direction of the Sun will, during an eclipse, appear to radiate from a considerable arc of the Moon's limb, the amount and direction of the inclination to the normal being governed by the conditions above indicated.

A considerable interval between two such sets of streamers would result in "gaps" or "rifts" in the corona. When such eruptions actually take place on the Sun's limb, those streamers which have greatly inclined initial directions of motion may evidently also become visible.

Referring now to the coronal photographs of the April eclipse, and numbering the quadrants 1, 2, 3, 4, in the order NE, ES, SW, WN, referred to the projection of the Sun's axis, the observed forms are explained as follows:

In the first quadrant, streams both on this and the farther side of the Sun are seen in projection, with a preponderance of the former. The same distribution will account for the forms in the second quadrant In the third quadrant the streams of the farther

hemisphere are almost completely eclipsed by those of the nearer hemisphere. Finally, in the first half of the fourth quadrant only the streams of the nearer hemisphere are seen, while the second, or polar half of the same quadrant, has practically the same arrangement as the first half of the first quadrant. The structure in the equatorial regions (giving the appearance of two opposite magnetic poles on the Sun's equator) is in agreement with the theory that the streams of matter are ejected from the spot-zones and are subject to gravitational influences. During this eclipse several powerful eruptions were in action near the Sun's west limb.

A discussion of all the matter available will be embodied in a "Report" on this eclipse, to be subsequently printed.

LICK OBSERVATORY, August 10, 1893.

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## PHOTOGRAPHS OF COMET *b*, 1893.

BY PROFESSOR W. J. HUSSEY.

During the period of its greatest brightness, I have secured a number of photographs of this comet, using the CROCKER telescope of the LICK Observatory. The objective of this telescope is a portrait lens of nearly 6 inches aperture and with a focal length of about 31 inches. The plates used were 8 x 10 inches, coated with an unusually sensitive emulsion by CRAMER.

The nucleus of this comet is bright and starlike. The coma is dense and nearly circular, having a diameter of about $\frac{1}{4}°$. There are very faint extensions of the coma in directions at right angles to the tail. These extensions are short. The tail has been bright. So far as these observations go, it was brightest on the evening of July 13. At that time it could easily be traced more than 12° with the naked eye. In most of the photographs it extends beyond the limits of the plates, and exhibits marked and interesting changes from night to night. Some of these peculiarities will be noted.

Tuesday, July 11, $9^h\ 00^m$ to $9^h\ 20^m$. This negative shows the comet with a multiple tail. Four distinct branches proceed from the nucleus, the angle included between the outermost ones being

approximately 30°. The middle branches are much the brightest, and at some distance from the nucleus they divide into numerous streamers. These are so faint, on the negative, that it is not possible to determine their number nor the exact manner of their branching. A longer exposure would have given better results, but it was impossible, owing to the low altitude of the comet and the position of the guiding telescope.

Wednesday, July 12, $9^h 00^m$ to $10^h 12^m$. Four distinct branches of the tail spring from the nucleus and include an angle of nearly 40°. The central branches are the brightest. Beginning on the north is a short branch, 1½° long, very gradually diminishing in brightness as the distance from the nucleus increases. The branch next to it is bright and nearly straight. It broadens a little as the distance increases and fades away at about 7°. The next is the brightest of the branches, and the most complicated in structure. It is composed of numerous streamers which in places appear to be interlacing and in others to offer a somewhat doubtful suggestion of an outward spiral motion. Fully 9° of this branch is shown on the plate. The fourth branch is short and without special interest.

Thursday, July 13, $9^h 10^m$ to $10^h 20^m$. The tail has a complicated structure. In it there are several condensations. The distances of the principal ones from the nucleus are approximately 1°.4, 1°.8, 3°.6 and 6°.0. The second of these is much the brightest. It and also the third are sources of dense and strongly curved secondary streamers, giving the tail somewhat the appearance of SWIFT'S comet of last year, as shown in Dr. BARNARD'S photographs. In the present case all the condensations belong to the central parts of the tail. The branches forming the other parts of the tail, in contrast with the central one, are very straight, and with spaces of unusual clearness between them. The four branches of the tail shown in previous negatives are losing their identity. They can still be identified, but with difficulty.

Friday, July 14, $9^h 8^m$ to $10^h 28^m$. For 12° the tail can be traced on the plate. The peculiar condensations of last night have very nearly disappeared. Throughout, the tail is much fainter, and diminishes in brightness very gradually. Near the coma seven branches of the tail are distinctly shown. They are straight, and, excepting the central ones, are short.

Saturday, July 15, $8^h 45^m$ to $9^h 30^m$. Near the nucleus the tail has several distinct branches, of which the central one is the

brightest, and, excepting it, they are all straight. It divides at about 1° from the nucleus and near the point of division it is strongly curved. The central part of the tail is about 1° wide at 6° from the nucleus.

Sunday, July 16. The comet presents essentially the same appearance as last night. The central part of the tail broadens a little more rapidly. The streamers are numerous.

Tuesday, July 18, $9^h\,01^m$ to $10^h\,21^m$. In contrast with all the previous negatives, the tail is single near the nucleus. It is very slender at its departure from the coma, and, for about 1°, broadens slowly. Then it begins to divide with numerous streamers. Lateral streamers on the southern side of the tail are common, but not long. The principal streamers are not equally dense in all their parts. Here again is a doubtful suggestion of outward spiral action.

PALO ALTO, CAL., July 22, 1893.

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## THE SPECTRUM OF COMET *b*, 1893.

By W. W. CAMPBELL.

The spectrum of this comet has been observed here both visually and photographically, and a large number of new bright lines have been detected.

### VISUAL OBSERVATIONS.

The yellow, green and blue bands appear with their usual intensities, but their less refrangible edges seem to be completely resolvable into bright lines. Wave-lengths were determined for two lines in the yellow band, three in the green and one in the blue; and several other ill-defined lines were seen in the yellow and blue bands. A red band at *w. l.* 601 and violet bands at *w. l.* 434 and *w. l.* 421 are easily visible. The wave-lengths obtained are given in the following table. The fifth column contains KAYSER and RUNGE'S wave-lengths of the edges of the corresponding carbon bands.

The continuous spectrum of this comet is relatively much

fainter than I have observed in any comet of the past two years, though easily visible from about 6300 to 4100.

| July 11. | July 12. | July 17. | July 25. | Carbon Bands. | Description of Bright Lines and Bands. |
|---|---|---|---|---|---|
| 600 | 601 | ...... | ...... | 619-595 | Maximum of red band, broad, faint. |
| 562 | ...... | ...... | ...... | | Red edge of yellow band. |
| ...... | ...... | 5633 | ...... | 5635 | Very faint line, terminating yellow band. |
| ...... | ...... | 558 | ...... | 5585 | Bright line in yellow band. |
| 5162.1 | 5161.8 | 5163.9 | 5163.6 | 5165 3 | Very bright line terminating green band. |
| 5124 | 5127 | 5128 | ...... | 5129 | Very bright line in green band. |
| ...... | ...... | 509 | ...... | ...... | Very bright line in green band. |
| 4734 | ...... | ...... | ...... | 4737 | Red edge of blue band. |
| ...... | ...... | 4734 | ...... | 4737 | Bright line terminating blue band. |
| ...... | 434 | ...... | ...... | ...... | Bright region in continuous spectrum, faint. |
| ...... | 421 | ...... | ...... | ...... | Bright region in continnous spectrum, faint. |

PHOTOGRAPHIC OBSERVATIONS.

Two photographs of the region *w. l.* 487–387 were obtained. They show five lines in the less refrangible side of the blue band. The rest of this band does not resolve into bright lines, but diminishes gradually in brightness in both directions from the maximum near 4680, extending from about 4730 to 4610.

The two violet bands observed visually at *w. l.* 434 and 421 are shown to consist of five and two lines respectively. The results for these plates are given below; and likewise, in the last column, the wave-lengths of the corresponding bands and lines of carbon and cyanogen as given by KAYSER and RUNGE.

| July 13. | July 16. | CARBON. | Description of Bright Lines. |
|---|---|---|---|
| 4736 1 | 4736 3 | 4737.2 | Very bright line, the head of blue band group. |
| 4716 7 | 4715 2 | 3715 3 | Very bright line in the blue band group. |
| 4698 1 | 4696.0 | 4697.6 | Very bright line in the blue band group. |
| 4683 4 | 4683 0 | 4684 9 | Brightest line in the blue band group. |
| 4674.8 | 4675.4 | ...... | Apparently a very bright line, in the blue band group, but not well separated from 4683. |
| 4366.3 | 4366 1 | (4365.0?) | Very bright line. |
| 4350.3 | 4349 | ...... | Very faint line. |
| 4333.9 | 4335 8 | ...... | Faint line. |
| 4313.2 | 4312.7 | ...... | Very bright line. |
| 4298.7 | 4298 0 | ...... | Very bright line. |
| 4253 | 426 | ...... | Very faint line. |
| 4235 | 4234 | ...... | Very faint line. |
| | | CYANOGEN. | |
| 4214.3 | 4214.2 | 4216.1 | Very bright line. |
| 4196 7 | 4195 8 | 4197.2 | Bright lines. |
| 4178 | ...... | 4180 7 | Very faint line, uncertain. |
| 4126 | ...... | 4128.1 | Faint line. |
| 4098 0 | 4097 8 | 4099 2 | Bright line. |
| 4071.8 | 4073 5 | 4073 7 | Bright line, probably double, at 4075 and 4069 |
| 4052.4 | 4052 2 | 4053 3 | Bright line. |
| 4043 9 | 4042 3 | ...... | Bright line. |
| 4017.1 | 4021 4 | ...... | Bright line. |
| 4011 2 | ...... | ...... | Faint line. |
| 3988 | 3988 | ...... | Very faint line. |
| 3881 2 | 3881 3 | 3883.5 | Very bright line, probably the brightest i[illegible] spectrum. |
| 3870 0 | 3869 9 | 3871 5 | Bright line, broad, resembles a band, more refrangible edge faint. |

The agreement of the comet spectrum with the strong bands and lines in the carbon and cyanogen spectra is perfect, within the limits of error, except that the wave-lengths for the comet are systematically less by one or two tenth-metres than KAYSER and RUNGE'S results. At first I was inclined to attribute the discordance to the large flexure of the spectroscope when the great telescope is in nearly a horizontal position. But the same discordance exists also in the visual observations, which are not affected by flexure. An explanation may possibly be found in the fact that in the various spectra we have to deal with unsymmetrical bands, to some extent, rather than with lines.

The photographs of KAYSER and RUNGE do not include the carbon line at 4675; but it has been observed by HASSELBERG and by WATTS; and the photographs of the spectra of Bunsen flames and of cyanogen flames made by H. W. VOGEL show the five lines in the blue band and the unresolved part of the band exactly as observed by me in the comet spectrum. KAYSER and RUNGE'S work does not cover the region 4366–4234; but VOGEL'S photographs of the cyanogen spectrum contains lines which probably are identical with the comet lines at 4366 and 4313, and possibly with a few others.

All the observations were made with a dense 60° prism.

The 36-inch telescope presents several positive disadvantages for comet spectrum work, of which I may mention two.

The ratio of focal length to aperture, 19:1, is much larger than exists in small telescopes, and hence the latter would form much brighter images on the slit-plate than the former.

The guiding in photographic work with the long telescope is difficult with low and rapidly moving objects.

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## COMPARISON OF THE NEW STAR SPECTRUM WITH THE SPECTRA OF FIVE WELL-KNOWN NEBULÆ.

By W. W. CAMPBELL.

The earliest observations of the August, 1892, spectrum of *Nova Aurigæ* convinced me that it was nebular. There was not the slightest resemblance to any other known type. The continuous spectrum was extremely faint, as in the case of the

planetary nebulæ; the spectrum consisted almost wholly of isolated bright lines; the three brightest lines had the relative positions and intensities of the three characteristic nebular lines; and a hasty examination of four well-known nebulæ resulted at once in finding eight other nebular lines which corresponded to eight of the prominent lines in the new star. Without tabulating the results of the comparison with nebular spectra, I stated, in September and October, that "The spectrum is that of a planetary nebula, * * * Nearly all these lines have been found either in the planetary nebula Σ 6 or in the *Orion Nebula*; the lines in *Nova's* spectrum, however, being displaced four or five tenth-metres towards the violet."

A question having been raised by Dr. and Mrs. HUGGINS, and by Professor VOGEL*, as to whether the spectrum is really nebular or not, I made a few more visual and long-exposure photographic observations of nebular spectra. Without any difficulty I found five additional nebular lines, which also exist in the new star. The wave-lengths of all the bright lines thus far observed by me in five nebulæ and in the new star are herewith tabulated:

| Orion Nebula. | G. C. 4390. Σ 6. | N. G. C. 7027. | G. C. 4964. | G. C. 4373. | *Nova Aurigæ.* |
|---|---|---|---|---|---|
| $D_3$ | 5876 | $D_3$ | .... | .... | .... |
| .... | .... | 5751 | .... | .... | 5750 |
| .... | .... | 5412 | ... | .... | .... |
| .... | .... | 5313 | 532 | .... | .... |
| 5007 | 5007 | 5007 | 5007 | 5007 | 5002 |
| 4959 | 4959 | 4959 | 4959 | 4959 | 4954 |
| 4862 | 4862 | 4862 | 4862 | 4862 | 4857 |
| .... | 4743 | 4743 | 4744 | .... | .... |
| 4713 | 4714 | 4716 | 4714 | .... | 471 |
| .... | 4687 | 4688 | 4686 | .... | 4681 |
| 4661 | 4663 | .... | 4663 | .... | .... |
| .... | 4637 | 4631 | 4640 | .... | 4630 |
| .... | 4610 | .... | .... | .... | 460 |
| .... | 4595 | .... | .... | .... | .... |
| .... | 4574 | ... | .... | .... | .... |
| .... | .... | .... | .... | ... | 451 |

* Professor VOGEL inclines to the view that the bright lines are chromospheric.

| Orion Nebula. | G. C. 4390. Σ 6. | N. G. C. 7027. | G. C. 4964. | G. C. 4373. | *Nova Aurigæ.* |
|---|---|---|---|---|---|
| 4473 | 4473 | .... | 4472 | 4472 | 4466 |
| 4390 | 4390 | .... | .... | .... | 438 |
| 4363 | 4364 | 4363 | 4364 | 4363 | 4358 |
| 4341 | 4341 | 4341 | 4341 | 4341 | 4336 |
| 427 | .... | .... | .... | .... | 426 |
| 424 | .... | .... | .... | .... | 423 |
| 4102 | 4102 | 4102 | 4102 | 4102 | 4098 |
| 4067 | .... | .... | 4067 | 4067 | .... |
| 4026 | 4026 | .... | 4026 | 4026 | .... |
| 3969 | 3969 | .... | 3969 | 3969 | 396 |
| 3889 | .... | .... | .... | .3888 | ... |
| 3868 | 3868 | .... | 3868 | 3867 | .... |
| 3836 | .... | .... | .... | .... | .... |

I have omitted from my original list of *Nova* lines those at [5570] and 5268, for the reason that they were too faint to permit an accurate determination of their wave-lengths. I have not searched for lines in the nebulæ at those places, since the new star lines are not well enough fixed to make a successful search of any value, but Professor VOGEL has observed faint lines in some of the nebulæ at 5540 and 5270, which could easily be identical with the two *Nova* lines observed by me.

I am not certain that any of the nebulæ contain a line near wave-length 451; but all the other *Nova* lines can be said to be matched perfectly in one or more of them, allowing for the fact that the *Nova* lines were shifted (in August and September, 1892) about five tenth-metres towards the violet. The *Nova* spectrum differs no more from the nebular spectra than the nebular spectra differ from each other; and as it resembles the nebular type perfectly, and bears no resemblance to any other known type, there can be no reason for changing my statement made last year that "'the spectrum is that of a planetary nebula."

Dr. and Mrs. HUGGINS began to observe the new star spectrum in February, 1893. Their observations* were confined entirely to the three principal lines in the spectrum, and indeed almost wholly to the brightest one of the three. They write that

* Described in a paper recently read before the Royal Society of London.

as soon as they directed the spectroscope to the star (February 1, 1893) they saw at once, even with one prism, that the two principal bright bands which had been described as the "nebular lines" were in strong contrast with those, not single lines, but broad bright spaces, diffused at the ends and irregularly bright, which they suspected to be groups of bright lines.

These characteristics of the lines agree perfectly with those described by me one year ago, in my first article on the *Nova*, except that in addition I observed several changes in the appearance of the brightest line. At that time I wrote: "* * * The difficulties in the way of deciding the question arise not from the faintness of the lines, but from their great breadth. They are more diffuse than those of any of the planetary nebulæ which I have observed. With the grating the line $\lambda$ 5002 is at least eight tenth-metres broad, with diffuse edges, and a brighter central region about four tenth-metres broad. On August 30 the line was suspected to be double, and the grating measures of that night refer to a point midway between the two condensations. On September 7 the measures refer to a point of maximum brightness slightly less refrangible than the centre of the line." (See *Astronomy and Astro-Physics*, October, 1892, p. 718.)

Further, I have *always* described the lines as abnormally broad, and have observed that the appearance of the brightest line *changes*. On August 23, 1892, I measured the positions of two apparent maxima at wave-lengths 5005.9 and 5000.3. In September, October and November,* 1892, the maximum intensity was at the centre of the band. In February and April, 1893, the band was broader and nearly of uniform intensity throughout. At no time has there been any excuse for making an error of one tenth-metre in measuring the wave-length of the centre of the band.

As a result of further observations Dr. and Mrs. HUGGINS conclude that the bands at $\lambda$ 501 and $\lambda$ 496 consist of lines more or less bright upon a feebly luminous background, with possibly some absorption lines. Their work in the rest of the spectrum was confined to satisfying themselves, "by a direct comparison, that the line about F was really the hydrogen line in that region."

They wish to speak at present with great reserve concerning the character of the spectrum, since the observations are in-

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* See *Astronomy and Astro-Physics*, February, 1893, p. 149

complete; but they "do not regard the circumstance that the two groups of lines above described fall near the positions of the two nebular lines as sufficient to show any connection between the present physical state of the *Nova* and that of a nebula of a class which gives these lines."

I can readily assent to that conclusion.

But in interpreting the spectrum of *Nova* we must not limit ourselves to our knowledge of those two bands or groups of lines. The rest of the spectrum must also be considered. Now, Dr. and Mrs. HUGGINS, and several other observers, have found that the intensities and relative positions of the three most prominent lines or bands in this spectrum agree *perfectly*, within the limits of error, with those of the three most prominent nebular lines*. I have observed nineteen lines in the *Nova*, eighteen of which may be said to correspond perfectly to lines in the nebulæ. Herr VON GOTHARD has observed seven lines, six of which he believed to exist in the spectra of several nebulæ. Four of these six coincide with four lines in my list, and the other two are in the ultra-violet, quite beyond the limits of my photographs of the *Nova* spectrum. Now, if only the brightest two of the twenty-one known lines were broad bands or groups of lines, and the other nineteen were narrow and well-defined, a question might possibly be raised as to the origin of the two groups. But such is not the case.

The "line about F" is seen with the large telescope to be a band, apparently identical in form with those at the positions of the two chief nebular lines; and likewise, with certainty, those at 463 and 436. Whether the fifteen fainter lines and the one at $\lambda$ 575 are also very broad, it is impossible now to say; but in all probability they are. If any *one* of these bands consists of a group of lines, it is very probable that they *all* do; and it would not, then, be a question of identifying each line in each group with some chemical element, but of observing *the arrangement of the lines in the groups*, in the hope of solving the problem of whether the *Nova* is *one* nebula, or a system of *several* nebulæ.

The lines in the February, 1892, spectrum occupied in general the positions of the solar chromosphere lines: those lines were

* My recent observations of these three bands in *Nova* give for their wave-lengths, 5006.0, 4958.3, 4860.2. These wave-lengths have increased or decreased simultaneously since August, 1892, and the intervals between them are the same as in the case of the well-known nebulæ.

broad, and many of them were multiple; but those facts did not prevent us from arguing that the spectrum was chromospheric.

The lines in the present spectrum do not occupy the positions of the prominent lines in the February, 1892, spectrum, nor the positions of lines in the solar chromosphere, nor the positions of the lines in any of the bright line stars; *they do occupy the positions of the lines in the nebulæ;* the spectrum resembles nebular spectra as closely as well-known nebular spectra resemble each other: therefore the spectrum is nebular, and the fact that the lines have remained broad, or may have remained multiple, does not militate against the theory.

MT. HAMILTON, August 11, 1893.

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## SOLAR ECLIPSE, OCTOBER 9, 1893.

TIMES OF BEGINNING, ENDING, POSITION-ANGLES, ETC., FOR THE FOLLOWING PLACES IN THE STATE OF WASHINGTON.

| | SEATTLE. Lat. 47° 35′ Long. 8h 9m 20s | | CHEHALIS. Lat. 46° 40′ Long. 8h 11m 52s | | SPOKANE. Lat. 47° 40′ Long. 7h 49m 40s | |
|---|---|---|---|---|---|---|
| | BEGINS. A. M. | ENDS. P. M. | BEGINS. A. M. | ENDS. P. M. | BEGINS. A. M. | ENDS. P. M. |
| | H. M. S. | H. M. S. | H. M. S. | H. M. S. | H. M. S. | H. M. S. |
| Pacific Standard | 10 27 20 | 12 31 9 | 10 24 23 | 12 32 52 | 10 41 13 | 12 32 9 |
| Local ......... | 10 18 00 | 12 21 49 | 10 12 31 | 12 21 00 | 10 51 33 | 12 42 29 |
| Duration .. . | 2h 3m 49s | | 2h 8m 29s | | 1h 50m 56s | |
| Moon's Hourly Motion in Relative Orbit... | 1298.9″ | | 1289.5″ | | 1296.3″ | |
| Magnitude . . | .29 | | .31 | | .22 | |
| Position Angle | S. of W. 3° 34′ 57″ | E. of S. 4° 5′ 23″ | S. of W. 1° 54′ 20″ | E. of S. 5° 30′ 16″ | S. of W. 10° 21′ 18″ | W. of S. 0° 48′ 22″ |

The position angle has been located with reference to the nearest point of the quadrant on the Sun's disc, and not from the north towards the east, as is usual.

As this eclipse is annular, it is of some interest to know how much the shadow lacks of reaching the earth. I have made a computation, and have reached the following results:

Denote the Sun's parallax by $\rho$ and the Moon's by $\rho'$; the Sun's semi-diameter by $s$, the Moon's by $s'$. Then the Moon's parallax at the Sun is $\frac{s\rho'}{\rho'-\rho}$; and the Sun's parallax at the Moon is $\frac{\rho s'}{\rho'-\rho}$. The semi-angle of the Moon's shadow is the difference between these values, or 16′ 3.8″ — 2.35″ = 16′ 1.45″. Taking the Moon's real semi-diameter at 1081 miles, we have

$$\text{length of shadow} = \frac{1081}{\sin(16'\ 1.45'')} = 231{,}913 \text{ miles.}$$

The Moon's parallax is 55′ 55.4″; and with this value the Moon's distance from the Earth's center is 243,380 miles. If from this we take the length of the shadow, 231,913, we have 11,467, which is the amount which the vertex of the shadow lacks of reaching as far as the Earth's center. If from this we take the Earth's radius 3959, there is left 7508, which would be the distance in miles from the vertex of the shadow to the Earth's surface, ***provided the axis of the shadow passes through the center of the Earth.*** But in fact, the axis of the shadow does not pass through the Earth's center. The declinations of the Sun and Moon are both south, and the eclipse is central at apparent noon in Lat. 12° 27′ 36″ north. It follows that the axis of the shadow must strike the Earth obliquely, and as a consequence the distance from the vertex of the shadow to the Earth's surface, on the line of the axis, is somewhat increased.

If we calculate the Moon's true zenith distance, and the Moon's parallax in altitude, at the latitude 12° 27′ 36″ N. the Moon's distance from this point (where the eclipse is central at apparent noon) can be obtained by the following simple method: Denote the zenith distance by Z, the parallax in altitude by q, and the Earth's radius by R; then, sin q : sin Z :: R : Moon's distance. This gives 239,770 miles, the Moon's distance from the point where the eclipse is central at apparent noon. This, diminished by the length of the shadow gives 7857, which is the distance in miles from the vertex of the shadow to the Earth's surface on the line of the axis.

ORRIN E. HARMON.

CHEHALIS, Lewis Co., Wash.

## NOTE ON THE DISCOVERY OF COMET *b*, 1893.

Dr. SWIFT has kindly furnished the following copy of a telegram received by him at 4 A. M. July 9:

[COPY.]

SALT LAKE, Utah, July 8, 1893.

To LEWIS SWIFT, WARNER Observatory, Rochester, N. Y.:

Naked eye comet observed 10 o'clock. Constellation Lynx. No telescopic observation possible. ALFRED RORDAME.

135 East 4th South St.

The following letter from Mr. RORDAME gives additional particulars:

SALT LAKE CITY, July 20, 1893.

PROFESSOR E. S. HOLDEN, LICK Observatory:

DEAR SIR—Accept my thanks for your kindly letter, and I regret very much that through some delay of the post office employees I did not receive it until this morning.

The comet was first seen by me on July 8, at 10 P. M., at Garfield, on the south shore of the Salt Lake, as a nebulous star of about the third magnitude, and knowing that there was no star of that magnitude in that place (Lynx), I telegraphed at once to Prof. SWIFT. The tail became quite apparent to the naked eye after a few minutes' scrutiny. On my arrival in this city I tried to get a view of it with my telescope, but found it impossible on account of high buildings.

Respectfully yours, (Signed) ALFRED RORDAME.

135 E. 4th South Street.

Dr. SWIFT also communicates the following letter lately received by him:

ALTA, Iowa, July 12, 1893.

PROFESSOR SWIFT, WARNER Observatory, Rochester, N. Y.:

DEAR SIR—I wish to make a correction in regard to the discovery of the comet in the constellation Lynx. The telegraphic reports state that the comet was discovered by Mr. ALFRED RORDAME of Salt Lake City, at 10 o'clock on Saturday night, July 8, 1893. Here at Alta, some fifteen hundred miles to the east of Salt Lake City, it was first seen at 9:30 the same evening by two young men, whose names, by the way, are JAMES MILLER and CHARLES JOHNSON. They communicated their discovery to Mr. DAVID E. HADDEN, a local U. S. weather observer and amateur astronomer, who will vouch for the truth of the statement. Thus, considering the difference in time, the right of discovery is rightfully due to the above-named gentlemen by two or three hours. I have the honor of

knowing enough of Professor SWIFT to believe that he wishes to see justice done. If you should wish to have further proof of my statements, please advise me, and it shall be forwarded without delay.

Very respectfully, (Signed) C. H. WEGERSLEV,
Editor *Advertiser*, Alta, Iowa.

The comet was independently discovered by M. QUÉNISSET at the Observatory of Juvisy (France), on July 9; and on this date and on the following day it was noticed by several persons. M. ROSO DE LUNA of Logrosan, Estremadura, Spain, observed an object at 15 hours local time of July 4. He supposed it to be a new star, and made a sketch of its position, which he sent in a letter dated July 6 to the Director of the Madrid Observatory, who received it on July 8. The position of the comet according to the sketch was:

1893, July 4. $15^h$ l. m. t. R. A. $= 5^h\ 3^m$, Dec. $= + 42^\circ.9$.

The position from Prof. LAMP's ephemeris is:

1893, July 4. $16^h$ Berlin m. t. R. A. $= 5^h\ 1.5^m$, Dec. $= + 42^\circ.7$.

M. ROSO DE LUNA is therefore a discoverer of the comet, who communicated his observation with promptness. The fact that he did not recognize it as a comet is analogous to the mistake of Sir WILLIAM HERSCHEL, who in 1781 did not recognize *Uranus* as a planet, but supposed it to be a bright comet.

The Regulations for bestowing the Comet-Medal of the Astronomical Society of the Pacific are printed in these *Publications*, Volume III, page 146. Article II declares: "The medal will be given to the actual discoverer of any unexpected comet." Article IV goes on to define who the actual discoverer is: "The discoverer is to make the discovery known in the usual way," etc. The usual way is to notify some observatory at once by telegraph or letter, in order that the fruits of the discovery may be reaped. This condition was fulfilled by M. R. DE LUNA, by Mr. RORDAME and by M. QUÉNISSET.

In view of the possibility of an earlier discovery than that of M. DE LUNA, it has been decided to postpone the award of the medal for the present.

The Committee on the Comet-Medal.

EDWARD S. HOLDEN,
J. M. SCHAEBERLE,
CHAS. BURCKHALTER.

1893, September 8.

# A SIMPLE GEOMETRICAL EXPLANATION OF CERTAIN APPARENTLY ABNORMAL FORMS OF THE SHADOW OF A SATELLITE DURING ITS TRANSIT ACROSS THE DISK OF *JUPITER*.

By J. M. Schaeberle.

The curious change of form which the shadow of a satellite undergoes during its transit across the disk of *Jupiter* has often been noticed and commented upon, but, so far as I am aware, no satisfactory explanation has been given.

The solution of the problem which I now give is of such amazing simplicity that all doubt as to its validity is removed, the proof involving only simple geometrical principles.

Let R denote the radius of *Jupiter;*
" r " " satellite radius of the shadow cone where it intersects the surface of *Jupiter*.

Then for a central transit this shadow cone intersects the surface of *Jupiter* in an oval, the linear length $d_o$ of the transverse diameter being given by the expression

$$d_o = R \cdot 2 \sin^{-1}\left(\frac{r}{R}\right) \qquad (1)$$

while the longitudinal diameter $d$ varies from $d = d_o$ near the center of the disk to a maximum value $d = d_m$ given by the expression

$$d_m = R \cdot \text{covers}^{-1}\left(\frac{2r}{R}\right) \qquad (2)$$

For central transits no errors will be introduced if, for greater simplicity, we use the chords $d'_o$ and $d'_m$ in place of the arcs.

The actual linear lengths of these chords are

$$d'_o = 2 R \sin\left(\frac{r}{R}\right) \qquad (3)$$

$$d'_m = 2 R \sin \tfrac{1}{2}\left(\text{covers}^{-1}\left(\frac{2r}{R}\right)\right) \qquad (4)$$

As seen from the Sun, these chords are of the same length in projection, since the one corresponding to $d_o$ is inclined 90° to

the planet's radius-vector, while the other makes the angle $\frac{1}{2}$ covers$^{-1}$ $\left(\frac{2r}{R}\right)$ with the same line; or

$$2\ R \sin\left(\frac{r}{R}\right) = 2\ R \sin^2 \tfrac{1}{2} \left(\text{covers}^{-1}\left(\frac{2r}{R}\right)\right) \qquad (5)$$

Now let $\theta$ denote the angular distance between the Earth and Sun as viewed from *Jupiter;* then the two limiting angles which the shadow chord makes with a line drawn to the Earth are

$$\theta + \tfrac{1}{2}\ \text{covers}^{-1}\left(\frac{2r}{R}\right) \text{ and } \theta - \tfrac{1}{2}\ \text{covers}^{-1}\left(\frac{2r}{R}\right)$$

The plus sign always refers to the chord at the visible terminator and the minus sign to the chord at the invisible terminator of *Jupiter.* Multiplying the actual length of each chord by the sine of its angle of inclination to the line of sight, we obtain the observed maximum (and minimum) values of the longitudinal diameters $r'_m$ of the shadow

$$r'_m = 2\ R \sin \tfrac{1}{2}\left(\text{covers}^{-1}\left(\frac{2r}{R}\right)\right) \sin\left(\theta \pm \tfrac{1}{2}\ \text{covers}^{-1}\left(\frac{2r}{R}\right)\right) \quad (6)$$

When $\theta = 0$, this expression becomes $r'_m = r_o$.

The minimum value of $r'_m$ can never be observed, as the shadow can only be seen when its angular distance from the invisible terminator exceeds the angle $\theta$.

The interpretation of equation (6) leads to the following fundamental law, which is almost self-evident.

Near the visible terminator of a superior planet the observed longitudinal diameter of the shadow of a satellite is always greater than the transverse diameter, and just the reverse is true when the shadow is near the invisible terminator; the two principal axes of the oval approach equality as the distance from the center of the disk diminishes. The distortions reach a maximum when the planet is in quadrature with the Sun. There are no distortions when $\theta = 0°$ or $\theta = 180°$.

Let us now apply these formulæ to the case of *Jupiter's* first satellite. From observation we know that very slight contrasts of light and shade in the case of *Jupiter's* satellite produce very marked contrasts when these are projected against the disk of *Jupiter;* consequently the umbra and more or less of the penumbra are involved in the diameter of the shadow observed, the effective diameter being a function of the brightness of the back-

ground against which the shadow is projected. Taking the effective diameter of the shadow at 2100 miles, we find from equation (1) that the actual length of the shadow near the terminator is about 14,500 miles, and the chord is inclined to the planet's radius-vector 9°.5. When *Jupiter* is in quadrature, $\theta$ is something over 11°; therefore, the chord 14,500 miles long is seen under the maximum angle 20.5. Consequently, its length projected on a plane normal to the line of sight is more than 5000 miles, or more than twice the vertical diameter of the shadow. When the shadow (complete) is internally tangent to the *full* outline of the planet, the observed horizontal diameter of the planet is, for the same value of $\theta$, but little more than one-fourth of the observed vertical diameter. It is probable that the assumed effective diameter, 2100 miles, is much too large for the shadow. If a less value is used, the distortion becomes increasingly greater. If the transit is not central, the distortions will be oblique near the terminators, and on the central meridian the axes will be slightly unequal. The exact geometrical form can now, of course, be predicted.*

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## PHOTOGRAPHIC VERIFICATION OF THE MOST DELICATE OPTICAL DETAILS ON THE MOON.

BY PROFESSOR L. WEINEK.†

Professor L. WEINEK, Director of the Imperial Observatory of Prague, has submitted to the Imperial Academy of Sciences of Vienna, as a continuation of his recent lunar studies, drawings of the ring-plane *Capella* and of the crater *Taruntius* C, enlarged forty times from photographs taken at the LICK Observatory. His explanatory remarks are as follows:

Drawings I and II represent the interior of the ring-plane *Capella*; drawings III, IV and V show the small crater on the north wall of *Taruntius*, which MAEDLER calls C.

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* When the elongated shadow falls centrally upon a very narrow bright belt or spot, an apparent contraction of the penumbral portion of the shadow will have a tendency to form an apparent double shadow, especially when the seeing is not first-class. This explanation requires that the two portions of the shadow shall always lie nearly along a radius, or along a line parallel to the circumference. In the former position the shadow will be near the visible terminator and appear larger than in the latter position, which will be near the invisible terminator of the planet. J. M. S.

† Translated for the Society by F. R. ZIEL, Secretary and Treasurer of the A. S. P., from the *Sitzungsbericht* of the Imperial Academy of Sciences at Vienna, July 6, 1893.

These five drawings are enlarged exactly forty times from the following photographs taken at the LICK Observatory :

I. From LICK Observatory negative, 1890, November 17. $6^h$ $8^m$ $35^s$ P. S. T.; moon's age, = $5^d$ $12.5^h$.

II. From LICK Observatory negative, 1890, August 31. $14^h$ $27^m$ P. S. T.; moon's age = $16^d$ $18^h$.

III. From LICK Observatory negative, 1890, November 16. $5^h$ $53^m$ P. S. T.; moon's age = $4^d$ $12^h$.

IV. From LICK Observatory negative, 1890, July 20. $7^h$ $53^m$ P. S. T.; moon's age = $4^d$ $3^h$.

V. From LICK Observatory negative, 1890, August 31. $14^h$ $27^m$ P. S. T.; moon's age = $16^d$ $18^h$.

Both pictures of *Capella*, in which the shadows are cast in opposite directions, have exactly the same position in reference to the Moon's meridian, so that the vertical lines of the reticle represent the direction of the meridian for this locality of the Moon.

The exact orientation was found by turning plates I and II in such a manner that the east crest of *Capella* and the east rim of crater D, northeast of *Capella* (which objects MAEDLER places in almost the same meridian), coincided with one of the vertical lines of the glass reticle, which was divided into spaces of one half-millimetre, and which was used in making the enlargement. In a similar manner the three drawings of the crater *Taruntius* C were located exactly alike, in reference to the meridian of the place, which is also shown by the vertical lines of the picture.*

THE CENTRAL PEAK IN *CAPELLA*.

Mr. C. M. GAUDIBERT of Vaison (Vaucluse), in writing to me on April 27, 1893, calls my attention to a small crater which he discovered on May 24, 1890, on the summit of the central peak in *Capella*, which he describes in the *Revue mensuelle d'Astronomie populaire*, Fevrier, 1892, p. 64, as being excessively small at the time of first observation; but at present he is able to see it without difficulty, so that Mr. GAUDIBERT is led to the belief that this summit-crater may have lately attained a larger diameter.

I was much interested by Mr. GAUDIBERT'S information, and proceeded to search for this crater on LICK Observatory plates of the year 1890, for the purpose of ascertaining whether the photo-

* These pictures will be published in the future.

graphic representation was inferior or superior to the optical observation.

Mr. GAUDIBERT states that during the whole of the year 1890, and until September 20, 1891, although he searched for this crater whenever opportunity offered, he was unable to verify his first observation; which is no doubt a proof that the optical observation of the crater was extremely difficult during the year 1890.

I had no trouble in finding this summit-crater on two plates (I and II) of 1890, with shadows falling in opposite directions, and was, moreover, led to the discovery of several formations of rills and some much smaller craters in the vicinity; the enlargement of 40 diameters (viz.: $0.28^{mm}$ on SCHMIDT'S map $= 0.50^{km}$) shows an exceedingly small crater (having a diameter of only $0.8^{mm}$) to the east, which is identified on both drawings I and II, as well by its position as by its size.

I may state that the round outline of this minute crater on plate II is of the same order as the lines of the faintest rills discovered photographically. I have found, after making numerous measurements, that the grain of the photographic plate, under an enlargement of 40 diameters, has a size of only 0.10 to 0.17 millimetres; this agrees well with Professor EDER'S measurements in *Die photographische Camera und die Momentphotographie*, 1892, page, 698, which place the size of the grain of quick dry plates at 0.003 to 0.004 millimetres; so that the grain is about five to eight times smaller than the diameter of the above-mentioned crater.

Plate I shows the summit-crater very clearly, and was taken at about the same age of the Moon as that on which the optical discovery was made, viz., May 24, 1890, the Sun being about 18° above the morning horizon; whereas for plate II the altitude of the Sun was about 28° above the evening horizon. The greater altitude of 10° in the latter case is probably the reason why the crater is not so plainly shown on plate II, where it is hardly more than outlined. The visibility of a crater is naturally also governed by its inner slope toward the west or east, as the case may be, and which is not known beforehand. In general the conditions exhibited on plate I appear to be more favorable for *Capella* than those of plate II.

The small crater discovered by GAUDIBERT on March 15, 1891, on the western slope of the central peak is well visible on

plates I and II; on the former with a distinct round outline without much shadow, on the latter with a shadow.

The first-mentioned manner of photographic representation of small craters is very interesting, and is quite frequently met with on the photographic plate, but as a rule becomes apparent only by strong magnification, and in many cases furnishes the proof of the existence of an optically observed crater, which, owing to the not quite favorable exposure conditions of the plate, had apparently been lost on the latter.

Southeast from the summit, at the base of the peak, there are three larger craters, of which the two outer ones can be identified on plates I and II without difficulty. The middle one, however, is barely visible on plate I, although quite plain on plate II.

Among the many small craters, including some as small as one-sixth of the diameter of the summit-crater on both pictures, which appear principally as perfectly circular outlines, and which can in some cases be traced on plates I and II (on plate I the Moon's distance from the Earth is a little greater than on plate II). We observe on plate II a circle of four distinct craters on the southwest wall of *Capella;* of these the most easterly one is also shown on plate I. A very delicate rill-formation, extending from the summit-crater in a southwesterly direction, and which is finally divided in the shape of a fork, can be identified with certainty on both plates.

Plates I and II show a great number of chains of delicate undulations, low elevations and faint rills, the general direction of which is perpendicular to the Sun. Among these we may mention several chains on the peak itself, which converge toward the summit-crater, and, therefore, probably originate in the latter.

Finally, I may mention that the time employed in the production of drawing I was 20½ hours, and ofdrawing II 25 hours.

Considering this relatively short time of drawing, it was possible, in both cases, only to make an exact drawing of the central peak, while the rest has only been sketched, although it is correct in reference to position and showing all important detail.

## TARUNTIUS C.

Plates III and IV, in which the shadows are cast in the same direction, and plate V, in which they fall in the opposite direction, show that there is another smaller crater at the bottom of

this crater, which, on plate V, gives the impression of being slightly convex, and has a small crater opening in its center.

The size and shape of this inner crater agrees well in all three cases.

The diameter along the meridian is equal to 3.5 millimetres, or 2.23 kilometres,* or 0.30 geographical miles on the enlargement of 40 diameters, whereas, the diameter of the inner crater-opening is 0.25 kilometres.†

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## THE CORDOBA DURCHMUSTERUNG.

By R. H. TUCKER, Jr., Astronomer in the LICK Observatory.

The completion of twenty degrees of the *Cordoba Durchmusterung* marks an epoch in that undertaking. The first ten degrees, from $-22°$ Declination, one degree North of the limit of *Schönfeld's Durchmusterung*, to $-32°$, forms Volume XVI of the *Cordoba Observations*, and has been already distributed to observatories and astronomers, The remaining ten degrees, to $-42°$ Declination, are in the hands of the printer, and will be included in another volume. The maps to accompany the volumes, giving all the stars of the catalogue, are, some of them, now being lithographed.

The two volumes give the places and magnitudes of more than 340,000 stars down to the tenth magnitude. As the region covered by this section of the *Durchmusterung* is three-tenths of the Southern sky, and but thirty three-hundredths remain to the pole, about half the surface included in the original scheme has been completed.

The observation of the twenty degrees has required five years of effective work for the two observers engaged upon it. During this period more than 1600 individual zones were taken, one hour long at the maximum, and one degree of Declination in width, except in portions of the Milky Way, where but 40' wide was possible. This covers the lap necessary between succeeding zones in Declination: the zones broken by clouds, or repeated from suspicion that the sky may not have been per-

* 1.38 English miles.
† .155 English miles.

fectly clear; the narrow ones of the Milky Way; those lost by failure of the chronograph to record; and short zones to fill in the gaps caused by the various sources of interruption. Some portion of the region South of 42° has also been observed.

Since the Moon deprived us of one-third the nights, and shortened the working hours of one-half the remainder each month, but one-third of the whole month could be counted upon for entirely dark nights. One-half the nights have been cloudy on the average, so that during the period over which the work extends, including the Revision, there has been an average of less than ten nights per month upon which satisfactory *Durchmusterung* observations could be made.

The maximum is reached in the month of August, the end of winter and the last of the dry season, when the average for the month was 12.8 nights. October, in the beginning of the rains, has the smallest average, 7.3; while, in the height of summer, January reaches 11.7 nights.

The periods of six months, corresponding to dry and wet seasons, give almost identically the same amount of observing weather. In the commencement four zones were taken each night, later increased to six, for some months; but, as recorders were not available for these longer nights, five zones have usually constituted a full night's observing. The greatest number in any one month was that of August, 1886, when sixty-seven zones were observed on eighteen nights.

The observer retained his position uninterruptedly during each zone, without removing his eye from the telescope. The number of stars in individual zones ranges from 300 to 1400, and 4500 have been observed in one night. Notwithstanding the large number of stars to be taken as they cross the scale in the center of the field, the collection and comparison of various zones covering the same region, shows that but few are omitted that have been estimated at any time as brighter than tenth magnitude. These have been looked up on Revision, and the great majority of those observed once only in the original zones as 9¾, have been found to be as faint as tenth magnitude, very often below that type.

The tenth magnitude as observed was an elastic type, and intended to include stars slightly in doubt as to falling within the limit; and when there might be a suspicion that the sky was not of the usual transparency, faint stars were purposely included.

Accordingly, those having but one observation as ten, have generally not been again looked up, and do not enter the catalogue.

The estimates of individual magnitudes have often, necessarily, been very hurried, especially since in the densest regions the stars do not lie uniformly distributed, but appear in irregular masses. In general, however, the estimates will not suffer from the need of quick judgment. Long-continued practice in just this class of work has given a facility and a steadiness to the observers that could be gained in no other way. The faculties are trained to alertness; there is usually no time for a second or revised estimate without risk of neglecting other stars hurrying on, and one's observing habit becomes molded to the needs of the service.

The observing was done in a perfectly darkened room, the scale for the determination of positions being visible against the starlit sky. None was carried on when there was a sensible amount of moonlight, nor when there was cloudy sky in the region at which the telescope was pointed.

The continuity of the work, its extensiveness, and the uniformity of the conditions under which it was performed, should render the magnitudes reliable. This is of primary importance, for, next to the completeness of the catalogue, its usefulness to the working astronomer will depend upon this feature.

The *Durchmusterung*, including the Northern one of ARGELANDER and that of SCHÖNFELD, serves as the basis of series of zones of accurate places of stars down to a limiting magnitude, brighter than the limit of the *Durchmusterung* itself. Such a series has been carried to completion in the Northern sky, under the auspices of the *Astronomische Gesellschaft;* the Albany and Cambridge Observatories having borne a part. The list of stars to be observed is taken directly from the corresponding *Durchmusterung*. The scale of the succeeding zone will be, perhaps insensibly, somewhat adapted to that of the working list. Uniformity is then essential throughout, and the type which limits the plan of the zone should be as nearly as possible the true one.

In current observing the astronomer has continually to refer to his *Durchmusterung*, to obtain the configuration of stars near some object whose place is to be determined, probably by differ-

ential measures. In identifying the stars, consistent magnitudes are nearly as useful an aid as the relative positions.

The places are given in the *Durchmusterung* with more than sufficient exactness to serve both purposes: to form a working list for observations of high precision, and for the identification of any star by its relative position to others. The maps will be less consulted, except for the brighter grades of stars, for this last purpose, than the catalogue itself. The formation of the catalogue lends itself to these uses with great facility.

The magnitudes were estimated to the nearest quarter, and since there are always two or more observations of each star, the mean gives the adopted magnitude to tenths. Comparing, during the progress of the current reduction, many regions covered by the same observer, and identical in two zones, so that all stars of one are included in the other, more than one-half the estimates agree in giving the same quarter, and the average difference of estimate is less than one-eighth of a magnitude.

The greatest differences are in estimates of the brighter stars, but these have been in large part estimated again during the Revision.

A useful check during the progress of the work was the count of magnitudes as observed, by grades, to test personal bias towards certain quarters. While the object of this was not to avoid any particular quarter in succeeding work, it served to attract the observer's attention strongly towards the need of exercising an even and wakeful judgment.

The accompanying percentage is the result of a large number of counts for the same observer, for the scale from nine to ten: the even ninth magnitude is in excess, while the large percentage of tenth shows the tendency to include fainter stars. Some of these last will fall into brighter grades in the catalogue, while many will be dropped, from having but one observation:

ESTIMATES OF MAGNITUDES BY QUARTERS.

| | | | |
|---|---|---|---|
| Brighter than 9 | mag. | Percentage, | .099 |
| 9 | " | " | .068 |
| 9¼ | " | " | .043 |
| 9½ | " | " | .096 |
| 9¾ | " | " | .146 |
| 10 | " | " | .548 |

Tests, by counts from the catalogue, of each tenth of a magnitude, show that the accumulation of observations has resulted in the whole scale being pretty fairly represented, with tendency to grouping at the even and half magnitudes. The table gives the percentage, as results of counts extending over the first ten degrees, for the first six hours, 29,000 stars having been counted.

The proportion of tenth magnitude stars indicates that this type undoubtedly includes those one-tenth of a magnitude fainter of the same scale, and probably somewhat more.

COUNT OF STARS OF THE CATALOGUE.

$0^h$ to $VI^h$ — $-22°$ to $-31°$

| | | | | |
|---|---|---|---|---|
| Brighter than | 7 | mag. | Percentage | .007 |
| | 7.0 | " | " | .002 |
| | 7.1 | " | " | .001 |
| | 7.2 | " | " | .002 |
| | 7.3 | " | " | .002 |
| | 7.4 | " | " | .001 |
| | 7.5 | " | " | .003 |
| | 7.6 | " | " | .001 |
| | 7.7 | " | " | .003 |
| | 7.8 | " | " | .003 |
| | 7.9 | " | " | .002 |
| | 8.0 | " | " | .006 |
| | 8.1 | " | " | .004 |
| | 8.2 | " | " | .005 |
| | 8.3 | " | " | .006 |
| | 8.4 | " | " | .005 |
| | 8.5 | " | " | .012 |
| | 8.6 | " | " | .009 |
| | 8.7 | " | " | .013 |
| | 8.8 | " | " | .011 |
| | 8.9 | " | " | .103 |
| | 9.0 | " | " | .025 |
| | 9.1 | " | " | .025 |
| | 9.2 | " | " | .026 |
| | 9.3 | " | " | .032 |
| | 9.4 | " | " | .034 |
| | 9.5 | " | " | .055 |
| | 9.6 | " | " | .066 |
| | 9.7 | " | " | .090 |
| | 9.8 | " | " | .092 |
| | 9.9 | " | " | .090 |
| | 10 | " | " | .354 |

The magnitudes observed were often tested during reduction of the observations, by comparison with the stars of the Cordoba Zone Catalogue, used to obtain the constants of reduction for the places of the *Durchmusterung*. These tests agree, over a long period, in giving a pretty consistent difference for the same observer of 0.17 mag. throughout the range from 7 to 9; the Zone Catalogue estimates being fainter. For stars fainter than 9 in the Zone Catalogue, the difference in the magnitudes at once increases, and it seems probable that the fainter estimates of that catalogue, especially ten, of which but few were made, were obtained under observing conditions less favorable than usual.

The proportion of D. M. stars, observed in the Zone Catalogue, was found to be 0.100; from the number used in the reduction of a large part of the work. But this is not a complete count.

The number of stars contained in the Zone Catalogue would give 33,000 as the proportional number from $-23°$ to $-42°$. Though not intended in any measure to be complete beyond the eighth magnitude, it could be considered as extending to an equivalent limit slightly fainter than 8.8 of the D. M. scale, the stars observed fainter than that limit balancing in number, approximately, those omitted between 8 and 8.8.

The percentages of stars of each magnitude, in the first six hours of the Northern ten degrees of the *Durchmusterung*, afford a test of the magnitudes themselves, on the basis of the distribution of the stars at distances corresponding to their brightness. The inference would be that tenth magnitude stars would be represented by 9.9 of the D. M. scale, and that the 10 of that scale would be mainly 10.1 and 10.2.

This is additional assurance that the catalogue is complete to the tenth magnitude, while any type of magnitude brighter is not likely to be more than one-tenth of a unit in error.

The probable error of a single observation of position, from a large number of determinations made during reduction, by comparing pairs of observations by the same observer, was $\pm 0.7^s$ in Right Ascension, and $\pm 0'.33$ in Declination. While in Right Ascension the probable error is less than half that of Declination in arc, it may seem large for transits; but in observing the brighter stars there is an uncertainty in estimating the instant of disappearance behind the scale, hardly to be compared with that of the bisection of a star by transit threads.

The probable error of the final place of the star is not much

affected by the error of reduction, it is mainly due to observation. But in Declination there is always a factor, due to the estimation of the divided scale to a certain fractional part—tenths of a division in this case corresponding to whole minutes of arc.

A test of personal bias in observing the declinations was made at various times during the reduction, by counting the units of the scale. This being reckoned from 20 to 80, the number 0 would naturally be in excess of the others; and as both 19 and 81 were often included, the units 1 and 9 show the effect. The table of percentages, which gives the result of a large number of counts at different epochs, for the same observer, shows also a tendency to avoid the unit 5.

COUNT OF UNITS OF DECLINATION SCALE.

| | | | |
|---|---|---|---|
| Scale | 0 | Percentage | .145 |
| " | 1 | " | .118 |
| " | 2 | " | .095 |
| " | 3 | " | .095 |
| " | 4 | " | .085 |
| " | 5 | " | .073 |
| " | 6 | " | .087 |
| " | 7 | " | .109 |
| " | 8 | " | .083 |
| " | 9 | " | .110 |
| " | 0 | " | .145 |

Following the original zones of the *Durchmusterung*, the Revision was devoted to clearing up all cases of doubtful identity, of magnitude, and of place, that were found in collecting and combining the various observations of the same region. This covered twenty months of effective observing, and was finished in the month of March of this year.

The reduction of this great mass of observations has required the nearly undivided labors of three men for the period which the observing has occupied. This carries it through publication, but the map-drawing is not included.

The current observing was usually brought up and reduced month by month; the combination followed when a sufficient amount had accumulated, and the collected results were given a thorough scrutiny preparatory to the Revision.

The prompt publication of the results of the *Durchmusterung*, following upon its vigorous prosecution, has been quite in the spirit which has governed the previous undertakings of the Cordoba Observatory.

# NOTICES FROM THE LICK OBSERVATORY.

PREPARED BY MEMBERS OF THE STAFF.

## THE DISTRIBUTION OF LAND AND WATER ON *MARS*.

[Extract from a private letter of Professor SCHIAPARELLI to Professor HOLDEN dated April 5, 1893. Printed by permission.]

* * * * * *

"You ask me my opinion of the idea of Professor SCHAEBERLE that the yellow areas of *Mars* correspond to the seas, and the dark patches to continents. I must declare that the whole result of my studies upon this planet is to induce me to reject this opinion. When we look at a body of deep water (the sea or a lake) from a height nearly vertically above it we invariably find it to be of a very dark shade. This is well known to all Alpine travellers. When one of the deep lakes, which abound in those mountains, is viewed from above, it appears as black to the eye as the ink which I am using at this moment, while the surrounding rocks appear far less dark when they are illuminated by the Sun. The cause of this is that the surface of pure water reflects barely $\frac{1}{50}$ of the incident vertical rays of light; the other $\frac{49}{50}$ enter the water, where they are completely absorbed if the water is 100 or 150 mètres in depth. From this I conclude that if seas exist in *Mars*, and if they are composed of a transparent liquid, it is beyond doubt that they would exercise a similar effect on light and absorb it almost completely. But if these seas were composed of milk or of melted sulphur, for example, my reasoning would naturally be without value.

Another argument in this question is furnished by the northern polar cap of *Mars*. As shown by my planisphere this cap is situated in the yellow regions of the planet. As this cap is in the process of diminution, it appears bordered by a dark zone which narrows progressively as the cap narrows, and only disappears when the polar cap has almost vanished. I suppose that

this dark border (which sends all round many ramifications in every direction) is nothing but the result of the melting of the snows of the northern polar cap. On this supposition the various phenomena which it presents can be very well explained, while the hypothesis of Professor SCHAEBERLE would lead to various difficulties.

Such are, for the moment, my ideas on this point. I recognize that they are, as yet, hypothetical in great part, and I am quite ready to modify them and to adopt other ones, if the latter are more accordant with observations. * * * * *

G. V. SCHIAPARELLI.

A note from Professor SCHIAPARELLI, dated June 7, acknowledges the receipt of some photographic copies of drawings of *Mars* made at the LICK Observatory in 1893. On these Professor SCHIAPARELLI remarks that he has recognized the doubling of the canals designated on his chart by the names *Ganges*, *Euphrates* and *Hydaspes*. The two first have been observed to be double on many occasions, but the doubling of *Hydaspes* is noticed for the first time. E. S. H.

REMARKS ON THE SURFACE-MARKINGS OF *MARS* [BY J. M. SCHAEBERLE].

To the objections which Professor SCHIAPARELLI raises against my interpretations of the surface-markings on the planet *Mars*, I have the following to say: My views are based upon two striking and well observed facts which I interpret as follows:

First—The *observed* gradual obliteration of surface details with increasing distance from the center of the disk of *Mars* towards the circumference indicates the presence of a spherical shell of matter (atmospheric) above the general surface of the planet, which absorbs and obstructs some solar light which would otherwise be reflected from the surface.

Second—The *observed* corresponding increase in the brightness of the disk of *Mars* with increasing distance from the center to the circumference indicates that the reflecting particles of matter in this spherical shell (atmosphere) are of such a density and reflective power that more light is actually reflected from this shell than from the general surface of the planet.

If these interpretations are in accordance with the actual conditions of things *above* the surface of *Mars*, it would seem that

certain arbitrarily assigned surface conditions would result in certain definite phenomena which could be predicted. Conversely, if certain phenomena are *observed*, the surface conditions can no longer be arbitrarily assigned.

Referring now to Professor SCHIAPARELLI's first objection, I wish to say that as the Alpine lakes are situated at altitudes which practically place them far above those terrestrial atmospheric strata, which cause a bright sky, his illustration is hardly a fair one.

Granting that water absorbs [illegible] of the normally incident light, I still cannot agree with him that the cause of the blackness of these lakes is mostly due to the great absorptive power of the water, indeed I even venture to say that if all the same incident light were *totally* reflected from the water's surface, these same lakes would, by contrast with other terrestrial reflections at the water's surface, appear quite as black.

In order to satisfy myself more fully on certain points, a few simple experiments were made, some of which are described below so that they can be easily repeated by anyone desiring to do so.

A vessel lined with black velvet cloth to prevent internal reflections, was filled with water and placed alongside of a basin of mercury vertically under the zenith shutters in the meridian circle room. The shutters are painted a light grey color on the inside.

When these shutters were opened so as to admit only a narrow line of sky light directly overhead, the reflection from each surface appeared as a line of *white* light, that one from the mercury surface being of course the brighter. When, however, the shutters were wide open and illuminated by direct sunlight, the sky by contrast was of a deep blue color in both reflecting surfaces, that from the water surface being of a deeper hue than the sky reflection from the mercury surface. In both reflections the sky appeared much darker than the shutters, the contrast being very much the greatest for the mercury surface.

An idea of the peculiar character of the zenith sky reflection can be gathered from the next experiment. The same water vessel was placed upon some ordinary pieces of grey rock, of which Mt. Hamilton is so largely composed, and which is very much brighter in sunshine than the vast fields of chapparal-covered ground, which by contrast with the sky actually appear black to the eye. A short tube was then so placed that equal areas of

sun-illumined rock and of water surface could be seen. An unbiased, intelligent individual being asked to look down the nearly vertical tube, actually maintained that the sky reflection from the water surface was brighter than the sun-illumined ground. Other unbiased observers invariably complained that the character of the two lights was wholly different, but agreed that the reflection from the ground seemed to be the most effective.

In the next experiment, the water surface, the rocks, and the writer (on an overhanging roof thirty feet above) were exposed to full sunshine. The sunlight reflected from my face and mirrored in the water surface below, was brighter than the reflection from the sun-illumined rock on which the vessel rested. So plain was the image, although at an equivalent distance of 60 feet, that the features were unmistakably recognized. The parts of my body in the shade appeared dark in projection against the reflected image of the deep blue zenith sky of Mt. Hamilton.

The reflected image of a white sheet of tissue paper held in the sunlight to represent a milky sky, was very much brighter than any terrestrial object beneath me, both by light transmitted through the paper and by reflection from the side exposed to the Sun.

From these and other experiments I infer that a milky sky will, when viewed from a point wholly exterior to the Earth, always cause a water surface to look brighter than a land surface. If the horizon of Mt. Hamilton were of the same deep blue color as its zenith, San Francisco Bay would appear black compared with the surrounding country even though the angles of incidence and reflection are such that but little light is absorbed by the water.

I would meet Professor SCHIAPARELLI'S second objection with the reply that during the last opposition I observed precisely the same phenomenon in the south polar regions which he describes as occuring near the north pole, as can be seen from those of my drawings already published, *and yet we both agree in making the south polar regions dark* The phenomena accompanying the gradual diminution in the size of the white south polar cap were closely watched, and while I can give no consecutive series of observations illustrating the changes which the north polar cap undergoes, all my drawings of the south polar region represent that part of the disk of *Mars* as dark and always most intensely so just along the edge of the white zone. I have all along been

inclined to attribute this marked variation in shade almost wholly to the sharp contrast between the excessive whiteness of the cap and the much less brilliant surface of the planet.

If this dark shading is simply a matter of contrast, no additional conditions are required to account for the observed phenomena of the north polar region regarded as a water area; the gradual melting of an ice cap covered with snow would offer a satisfactory explanation. At the south pole it would be a land area covered with snow.

An interpretation of my own observations and drawings, whatever their real value may be, leads to conclusions which are not compatible with the hypothesis that the darker irregularly-shaded markings correspond to water areas, and the uniformly bright portions to land areas. Such would in part be the case if *Mars* possessed no light-dispersing atmosphere; but the observed increase in brightness from the center of the disk to the circumference with an accompanying loss of surface detail, alone almost completely demonstrates the presence of an atmosphere highly charged with matter capable of reflecting the Sun's light. Such an envelope about *Mars* would of course tend to diminish the brightness of the land surfaces, and to very much increase the brilliancy of the water surface.

It seems to me that if the presence of such an atmosphere is taken for granted, the land and water-markings heretofore assigned must be interchanged. J. M. SCHAEBERLE.

LICK OBSERVATORY, August 20, 1893.

## EXPERIMENTS IN PHOTOGRAPHING THE CORONA.

We learn from a short note in *Astronomy and Astro-Physics* for August that Professor HALE, of Chicago University, recently attempted, from a station on Pike's Peak, to photograph the solar corona *without an eclipse*. This is a problem which HUGGINS, HALE and DESLANDRES have attacked in various ways, with considerable expectation of success. Professor HALE does not regard the observations with his "coronograph" as at all successful, possibly owing to the fact that the atmospheric conditions on Pike's Peak were surprisingly poor. We trust the various methods suggested will soon be put to the final test under perfect conditions. W. W. C.

## RESEARCHES IN STELLAR PARALLAX MADE AT THE OXFORD UNIVERSITY OBSERVATORY BY THE AID OF PHOTOGRAPHY [BY REV. CHARLES PRITCHARD].

[Extracts from a review by HAROLD JACOBY, printed in *V. J. S. der Ast. Gesell.*, 1893, p. 117].

The following table and extracts from the review above quoted are important and interesting:

TABLE OF PARALLAXES DETERMINED AT OXFORD.

| STAR. | $\alpha$, 1880.0 | $\delta$, 1880.0 | PARALLAX. | DATE OF OBSERVATIONS. |
|---|---|---|---|---|
| $\alpha$ *Androm.* | $0^h\ 2^m$ | 28° 26′ | +″.058 | 1889 Jan. to 1890 June |
| $\beta$ *Cassiop.* | 0 3 | 58 29 | + .157 | 1887 Oct. to 1888 Nov. |
| $\alpha$ " | 0 34 | 55 53 | + .036 | 1887 Dec. to 1888 Dec. |
| $\gamma$ " | 0 50 | 60 4 | + .018 | 1887 Aug. to 1888 Aug. |
| $\mu$ " | 1 0 | 54 20 | + .038 | 1886 Oct. to 1887 Oct. |
| $\beta$ *Androm.* | 1 3 | 34 59 | + .074 | 1889 June to 1890 Sept. |
| $\alpha$ *Urs. Min.* | 1 15 | 88 40 | + .078 | 1887 Feb. to 1888 July |
| $\alpha$ *Arietis* | 2 0 | 22 54 | + .083 | 1888 Jan. to 1890 Jan. |
| $\beta$ *Persei* | 3 0 | 40 30 | + .060 | 1890 Aug. to 1891 Aug. |
| $\alpha$ " | 3 16 | 49 26 | + .087 | 1888 Aug. to 1889 Aug. |
| $\beta$ *Tauri* | 5 19 | 28 30 | + .063 | 1890 March to 1891 Sept. |
| $\beta$ *Aurigæ* | 5 51 | 44 56 | + .062 | 1889 March to 1890 Sept. |
| $\gamma$ *Geminor.* | 6 31 | 16 30 | − .023 | 1889 March to 1890 Sept. |
| $\beta$ *Urs. Maj.* | 10 55 | 57 1 | + .088 | 1889 May to 1890 May |
| $\alpha$ " | 10 56 | 62 24 | + .046 | 1888 Dec. to 1889 Dec. |
| $\beta$ *Leonis* | 11 43 | 15 15 | + .029 | 1888 Dec. to 1890 June |
| $\gamma$ *Urs. Maj.* | 11 48 | 54 22 | + .095 | 1889 May to 1890 May |
| $\epsilon$ " | 12 49 | 56 37 | + .081 | 1888 Oct. to 1889 Nov. |
| $\eta$ " | 13 43 | 49 55 | − .046 | 1888 July to 1889 Aug. |
| $\beta$ *Urs. Min.* | 14 51 | 74 39 | + .029 | 1889 Jan. to 1890 Feb. |
| $\alpha$ *Coronæ* | 15 30 | 27 7 | − .037 | 1888 July to 1889 July |
| $\gamma$ *Draconis* | 17 54 | 51 30 | + .050 | 1891 Jan. to 1892 March |
| $\gamma$ *Cygni* | 20 18 | 39 52 | + .104 | 1888 May to 1889 May |
| $\epsilon$ " | 20 41 | 33 31 | + .129 | 1888 May to 1889 May |
| $61_1$ " | 21 2 | 38 10 | + .433 | 1886 May to 1887 May |
| $61_2$ " | | | + .435 | |
| $\alpha$ *Cephei* | 21 16 | 62 5 | + .058 | 1887 Nov. to 1888 Nov. |
| $\epsilon$ *Pegasi* | 21 38 | 9 20 | + .083 | 1889 May to 1890 Nov. |
| $\alpha$ " | 22 59 | 14 34 | + .081 | 1889 March to 1890 March |

"A glance at the table shows a distinct dependence of the parallaxes upon right ascension. If we take the means for each $6^h$, omitting 61 *Cygni*, on account of its large parallax, we find:

| R. A. | Mean Parallax. | No. of Stars. |
|---|---|---|
| $18^h - 24^h$ | $+0''.091$ | 5 |
| $0 - 6$ | .068 | 12 |
| $6 - 12$ | .047 | 5 |
| $12 - 18$ | .015 | 5 |

The variation with right ascension is small, but well defined. There can be no doubt that it is due to systematic error in the observations, whereby the results are made to depend upon the months in which observations begin and end. In fact, again omitting 61 *Cygni*, the eight stars observed from May to May, or November to November, exhibit a mean parallax of $+0''.100$, while the nineteen others come out with a mean parallax of only $+0''.041$. From the data given by the author, it is of course impossible to discover the immediate cause of systematic error, but it is doubtless of instrumental origin. Its numerical minuteness is no less remarkable than its very distinct character. This speaks highly for the accuracy of the results; yet, in the light of the above evidence, we are not justified in accepting the extremely small probable errors deduced by the author as reliable indications of uncertainty. The table of parallaxes proves that the stars in question are excessively remote, but it proves no more. With the possible exception of $\beta$ *Cassiopeiæ*, we cannot even regard the existence of measurable parallaxes as proven absolutely. Yet the general result of the entire research certainly shows the high value of the photographic method. Probably a few additional precautions, such as the use of a réseau to detect variations of the film, and a more thorough investigation of the optical distortion of the field, would tend to diminish still further the small systematic errors to which attention has been called."

## Photograph of the Moon, 1891, October 11.

The frontispiece of the present number represents one of the many attempts to find a method of reproducing the Lick Observatory moon negatives which should be at the same time satisfactory and not too expensive. The picture is *reversed;* the top of the plate is south, the right-hand border is west.

E. S. H.

## MR. RANYARD ON THE ORIGIN OF LUNAR FORMATIONS.

In *Knowledge* for August 1, 1893, Mr. RANYARD has a very interesting article on the origin of lunar formations, excellently illustrated by enlargements from the admirable moon-photographs made at the Paris Observatory by the MM. HENRY.

Mr. RANYARD discusses at considerable length the theory of the meteoric origin of lunar craters (see these *Publications*, Vol. IV, 1892, page 263), and pronounces adversely upon it. It is not possible to do justice to Mr. RANYARD'S paper by an abstract, without reproducing his illustrations, and this, unfortunately, is impracticable at this time. It must suffice, then, to refer those interested to this number of *Knowledge* (which also contains a suggestive paper by Miss CLERKE on our Sun considered as a bright-line star). E. S. H.

## SIX-INCH BRASHEAR REFRACTOR FOR SALE.

Mr. C. H. HOWIESON, Chippewa Falls, Wisconsin, writes that ill health obliges him to give up observing, and that he desires to sell his 6-inch BRASHEAR objective (of Jena glass), mounted equatorially. For particulars, apply directly to Mr. HOWIESON.

E. S. H.

## SCIENTIFIC VISITORS TO THE LICK OBSERVATORY.

(Messrs. EUGEN and STEPHAN VON GOTHARD and Dr HARKANYI.)

On July 8 we had the pleasure of receiving Messrs. EUGEN and STEPHAN VON GOTHARD, of Herény, and Dr. HARKANYI, of Budapest, at the LICK Observatory, and of showing them the results of present work in photography and spectroscopy. In return we were enabled to examine the originals of the beautiful photographs of nebulæ and of the spectra of stars and of nebulæ made at Herény with the 10-inch reflector, and to compare them with our own observations. The very few hours of their stay were most fully and profitably occupied. E. S. H.

## PROGRESS OF ASTRONOMY IN AMERICA, 1620–1893.

A paper by Professor HOLDEN, in the New York *Forum* for August, 1893, gives a brief account of the progress of Astronomy in America since its first settlement, and embodies the substance of a communication made to the Astronomical Society of the Pacific at its meeting of March 25, 1893.

## SCIENTIFIC VISITORS TO THE LICK OBSERVATORY.

(Dr. M. W. MEYER; Professor MAX WOLF.)

During the summer of 1893 we have had the pleasure of receiving several European astronomers at Mt. Hamilton, among them Dr. MEYER, the Director of the Urania Institute of Berlin (August 1) and Dr. MAX WOLF, Professor of Astronomy in the University of Heidelberg (August 4-6). The World's Fair of Chicago has done us a good service in bringing these gentlemen through seven hours of longitude, so that the remaining two hours seemed a trifling additional journey. It has been a sincere pleasure to welcome these guests from the far East. E. S. H.

## OBSERVATIONS OF 70 *OPHIUCHI* AND NEIGHBORING STARS, MADE WITH THE 36-INCH TELESCOPE OF THE LICK OBSERVATORY.

| | | | |
|---|---|---|---|
| 1893.58. | p = 313°.2 | s = 2''.41 | A and B |
| " | p = 40°.84 | s = 96''.81 | A " *a* |
| " | p = 205°.74 | s = 56''.00 | A " *b* |
| " | p = 226°.37 | s = 161''.69 | A " *c* |

**Four series upon three nights.**

R. H. TUCKER JR.

## MEASURE OF *STRUVE* 2145.

At the request of M. C. M. GAUDIBERT, Professor SCHAEBERLE examined the principal star of the wide double star *Struve* 2145, and found it to be a close double, as below.

A and B.

1893.643; $p = 49^\circ.0$; $s = 0''.36$; mags. 9.0 . . . 9.3; 36-inch telescope. E. S. H.

## THE RED STAR, DM. + 36° 4025.

While observing the WOLF-RAYET star DM. + 36° 4028, I noticed near it a very red star, DM. + 36° 4025, 9.5 magnitude, whose spectrum was found to be of SECCHI's type III. It is not contained in Dr. SCHEINER's compiled list, and has probably not been observed before.

Dr. SCHEINER's list assigns to DM. + 36° 4028 the type III b. It is II b, and should be excluded from the list.

W. W. C.

## THE *BIELAN* METEORS OF NOVEMBER, 1892.

It will be remembered that the display of the *Bielan* meteors which had been predicted for November 27, 1892, actually occurred the night of November 23, and was observed quite generally throughout the United States. No explanation was offered at the time to account for their unusually early appearance, except possibly that the meteor stream through which the Earth was passing late in November had become very broad and the meteors irregularly distributed in it. Dr. BREDICHIN of Pulkowa has now shown that a very simple and ordinary mathematical explanation exists. The following extracts are translated from his short paper on the subject in *Astronomische Nachrichten*, No. 3154:

"The observations of the *Bielan* meteors on the 23d of November in America have shown that the collision of the thick part of this swarm with the Earth last year occurred almost four days earlier than in the year 1885; that is, that the descending node of the stream moved almost four degrees west during the interval between November, 1885, and November, 1892.

"It shows that this retrogression was caused by the perturbations produced by *Jupiter* upon that part of the swarm which possesses an equal (or nearly equal) mean daily motion as, earlier, BIELA'S comet had.

"The perturbations were especially large from the end of 1889 to the middle of 1891, reaching their maximum value in July, 1890, at 306° heliocentric longitude of *Jupiter*, when that planet was only about 1.24 astronomical units from the place of the former (BIELA) comet.

"An approximate computation of the special perturbations for the whole interval of the appreciable influence of *Jupiter* gives a total retrogression of the node of something over 4°, and a decrease of the inclination of the orbit of about 0°.6"

The influence of *Jupiter's* attraction, then, changed the orbits of the meteors in *that part of the stream* to such an extent that they collided with the Earth on November 23 instead of November 27, as they would have done had that attraction not existed. Dr. BREDICHIN has shown that the perturbations of meteor streams may be of sensible magnitude; and they must hereafter be taken into account in the predictions of meteor displays.

W. W. C.

## THE DRIVING CLOCK OF THE 36-INCH EQUATORIAL.

Apropos of a recent discussion in the *Observatory* concerning the power required to drive equatorial telescopes, I will give the data for the driving clock of the 36-inch telescope.

A weight of 810 pounds falls through 17.4 feet, and propels the telescope 131 minutes. This is equivalent to $\frac{1}{307}$ horse power. The power really required is much smaller than this, as is shown by the fact that the clock alone requires about $2^m\ 20^s$ to pass from rest to full speed, while only $2^m\ 30^s$ are required when the clock is clamped to the telescope. W. W. C.

## COMET *b*, 1893.

The bright comet visible in July—the photographic and spectroscopic observations of which are described elsewhere in this number—was discovered independently by a large number of people. The telegrams notifying American observatories of the discovery gave the credit to Mr. ALFRED RORDAME, an amateur astronomer of Salt Lake City, Utah, who detected it by naked eye at 10 P. M. of July 8. He immediately notified Dr. SWIFT of Rochester by telegraph, who verified the discovery the next evening. Two gentlemen of Alta, Iowa, Messrs. JOHNSON and MILLER, claim to have seen it about 8:30 P. M. of July 8, but their announcement did not reach astronomers till several days later. On July 9 it was discovered independently by Mr. QUÉNISSET of Juvisy Observatory, France; by Mr. FILMER of Faversham, Kent, England; by Professor Boss of Albany; and by several others.

Late in August American astronomers learned from a published note by the director of the Madrid Observatory that the comet had been discovered on the morning of July 5 at Logrosan, Spain, by Mr. ROSO DE LUNA, who considered it to be a *new star* of the fourth magnitude, in the constellation *Auriga*, without, unfortunately, attaching to the discovery the importance which it merited. A letter by the discoverer, date Logrosan, July 6, received at the Madrid Observatory July 8, called attention to the "new star," and located it, by means of a chart enclosed, with reference to the surrounding stars. Cloudy weather at Madrid prevented a verification of the discovery. From the orbit of the comet, now well determined, it has been found that the position

which the comet must have occupied on the morning of July 5 is identical with that occupied by ROSO DE LUNA's new star, and there is no doubt of the identity of the two objects.

On July 11 the nucleus was of about the third magnitude, since when it has steadily and rapidly decreased, until now the brightness is less than one per cent. of that at discovery. On July 17 the nucleus was much more condensed than I had observed it on any date between July 11 and 16.

The comet was nearest to the Sun on July 7, its distance being about 0.67 of the Earth's mean distance from the Sun.

W. W. C.

### THE FRENCH ECLIPSE EXPEDITION TO SENEGAL.

M. DESLANDRES of the Paris Observatory and chief of the French expedition to Senegal to observe the solar eclipse of April 16, has communicated to the French Academy the principal results obtained on that expedition.

Aside from the photographs of the corona with several short cameras, which were successful, the observations were wholly spectroscopic. The spectrum of the corona was photographed as far up in the ultra-violet as the ordinary solar spectrum extends, and at least fifteen new coronal and chromospheric bright lines were detected. The light of the corona consisted of a strong continuous spectrum and bright lines. None of the ordinary solar dark lines were observed.

Another spectroscope was so arranged that the spectra of two portions of the corona on opposite sides of the Sun were photographed side by side. The two portions selected were situated in the plane of the solar equator, each about two-thirds of a solar diameter from the Sun's limb. Now the lines in the two spectra show a slight relative displacement, which M. DESLANDRES finds to correspond to a difference in the velocities of the two portions, relative to the observer, of from 5 to 7.5 kilometres. The conclusion drawn from this is that the corona is rotating about the solar axis from west to east along with the rest of the Sun, and at nearly the same rate.

These spectroscopic observations had never been attempted at previous eclipses, and we await with intense interest the publication of M. DESLANDRE'S final and full report. His experience in Senegal will undoubtedly be consulted by all who will form programmes for future eclipses.

W. W. C.

## THE CAUSE OF THE SUN SPOTS AND THEIR PERIODICITY.

Mr. W. T. LYNN suggests, in a letter to the August *Observatory*, that "the most probable cause of the periodicity of the solar spots" is that they are produced by a ring of meteors which revolve around the Sun and pass very near his body when in perihelion. If the period of revolution of the ring were assumed to be 11.1 years, the aphelion of the orbit would be slightly outside of *Saturn s* orbit. It would have to be assumed that, as in other well-known streams, the meteors were especially numerous in a particular part of the stream, and that a maximum of Sun spots is produced when this dense part is passing perihelion.

Mr. LYNN'S suggestions form an important modification of an old theory that the spots are due to the falling of meteoric matter upon the Sun. However, if it be held that the spots are caused *directly* by the fall of meteors, there still remains the enormous difficulty of explaining the distribution of the spots in two well-defined spot zones. Further, the meteors would approach always from the same direction in space, and the Sun spots should *originate* almost wholly on one hemisphere (with reference to space) of the Sun. W. W. C.

## THE NEXT TOTAL ECLIPSE OF THE SUN.

Astronomers are already beginning to plan for the next observable total solar eclipse, which occurs 1896, August 8. The line of totality passes through Norway, the island of Nova Zembla, central Siberia, northeastern China, and the island of Yezo in Japan. The eclipse at Yezo occurs at 3 P. M., and the duration of totality is about $2^{m}$ $40^{s}$. European parties will probably establish their stations, for the most part, in northeastern Norway and on Nova Zembla. American observers will undoubtedly go to Yezo, if the meteorological conditions are not too unpromising. When the results obtained at the April, 1893, eclipse have been published and discussed, it will be none too soon to prepare for the eclipse of 1896. Just what will be the most important problems left over from the recent eclipse cannot now be stated, but spectroscopic observations will undoubtedly occupy the most important places on the observing programmes. W. W. C.

## *JUPITER'S* SATELLITES.

The August number of *l'Astronomie*, in commenting upon certain observations of *Jupiter's* satellites made by the Arequipa

observers, asks whether the great LICK Observatory telescope could not for a time be devoted to this curious subject.

Results of satellite observations made here by various observers have been published at various times, and from some personal observations of the conditions prevailing at Arequipa I have little hesitation in saying that for the same observer the results given by the 13-inch telescope at Arequipa can not equal those given by the 36-inch on Mt. Hamilton; so that if it should finally turn out that certain marked peculiarities of the satellites had been observed at Arequipa which had not previously been observed here, this must be attributed to a superior diligence of the South American observers. J. M. S.

1893, September 1.

## THE CHANGE OF SENSITIVENESS IN DRY PLATES.

We quote some exceedingly interesting and useful remarks on the subject of dry plates in astronomical photography from a paper* by Professor MAX WOLF of Heidelberg University:

"* * It is not a pleasant experience to give an eight or nine hours' exposure to what is believed to be a highly sensitive plate, and then to find on development that the whole work has been thrown away, because the plate was really quite an insensitive one. The photographer who has had this experience repeated several times (as I have), very soon learns to become cautious. The only reliable test of sensitiveness, however, as I may here remark, is comparison by actual exposure to stars, the ordinary sensitometer tests being much too uncertain.

"Special caution is necessary in dealing with fresh plates. In the early part of my work I always noticed that new plates received from the makers were uniformly less sensitive than the previous ones, and that it was necessary to expose them a much longer time, so that it almost seemed as if the manufacture of dry plates was retrograding. * * The peculiarity is so strongly marked that during the last winter I was hardly able to obtain the same objects on a new lot of LUMIÈRE plates that I had previously obtained with the last plates of the same make, even with a three-fold greater exposure. * *

"I had, indeed, known earlier than this that plates changed

* The English translation in *Astronomy and Astro-Physics* for August, from the original in EDER'S *Jahrbuch für Photographie und Reproductions-technik.*

somewhat in sensitiveness when stored, but I could hardly expect that the change would amount to so much as a three-fold increase; and yet it was so. After five months the new LUMIÈRE plates, at first so slow, were as sensitive as the preceding ones, and exceeded in sensitiveness all my other plates. A similar change took place in those of other makers. * *

"The sensitiveness does not by any means increase indefinitely with the time. On the contrary, it soon reaches a maximum, which persists for some time, and after this the sensitiveness diminishes. * *

"For LUMIÉRE plates this time has been found to be from five to seven months after manufacture. By taking advantage of this fact much can be gained; sometimes, as I have said, an increase in sensitiveness of three or four times. * *

"From the foregoing the astronomer may take warning never to assume that plates made from the same emulsion are equally sensitive if they are used at different times. * * For the same reason it is also very difficult to determine beforehand what exposure should be given in order to obtain stars of a certain magnitude. It is quite impossible to do this (leaving out of the question changes in the transparency of the air), without taking into account the age of the plates." W. W. C.

## ACKNOWLEDGMENTS.

The success of the LICK Observatory eclipse expedition to Chile is largely due to the efficient and willing aid given by those with whom I came in contact—more particularly to the Regents of the University of California; the Government of Chile; JOHN KING, British Consul at Carrizal Bajo; the firm of GONZALEZ, IZAGA & Co., owners of the Mina Bronces mine; FILIPE BRAY, captain of the mine; and R. A. WALKER, engineer from Valparaiso.

A day or two before the eclipse the staff of volunteer assistants was farther increased by the arrival of the following gentlemen: W. F. GALE, the amateur astronomer from Paddington, N. S. W.; Mr. TIRAPEGUI, mining engineer from Santiago; J. J. AUBERTIN, author of several books of travel, and his private secretary, A. HOLE, both from London; Lieutenants BROWN, BODGER and WILSON, R. N., H. M. S. *Melpomene*. All of the above-named gentlemen took active parts in the observations during totality.

Special acknowledgments are also due E. J. MOLERA, C. E., San Francisco; Señor GUERRERO, Consul for Chile, San Francisco; WM. HENDERSON (of BALFOUR, GUTHRIE & Co.), Valparaiso; and Professor E. S. HOLDEN, every ready to do all in his power to assure the success of the expedition.

Finally, it remains to be chronicled that astronomical science owes a debt of gratitude to Mrs. PHŒBE HEARST, who made the expedition possible by generously offering to defray the expenses.

J. M. SCHAEBERLE.

## THE BINARY STAR $\beta$ 733 (85 PEGASI).

A recent observation of this most interesting of Mr. BURNHAM'S double stars indicates that the computed period of 22.6 years (which I deduced from his measures extending from 1878 to 1888) will be somewhat in excess of the true time of revolution, as can be seen from an inspection of the following residuals, which involve all the observations at hand. Each residual is found by subtracting the value given by my orbit (see *Astronomical Journal*, No. 248) from that given by direct measurement. All the observations were made by Mr. BURNHAM excepting the last, which was made by myself. Since 1878 the position-angle of the companion has increased 255°.

| Date. | Obs. — Comp. | | No. of Obs. |
|---|---|---|---|
| | $\Delta P$ | $\Delta s$ | |
| 1878.73 | − 6°.3 | + 0″.06 | 3 nights. |
| 1879.46 | − 2 .6 | + 0 .08 | 5 nights. |
| 1880.59 | + 1 .7 | − 0 .06 | 5 nights. |
| 1881.54 | + 7 .2 | − 0 .10 | 1 night. |
| 1883.75 | − 7 .2 | ....... | 1 night. (roughly) |
| 1888.69 | − 1 .6 | + 0 .04 | 5 nights. |
| 1889.59 | + 2 .1 | − 0 .09 | 4 nights. |
| 1890.55 | + 1 .6 | − 0 .23 | 4 nights. |
| 1891.56 | + 9 .3 | − 0 .18 | 3 nights. |
| 1893.65 | +12 .6 | + 0 .10 | 3 nights. |

J. M. S.

## Annular Eclipse of the Sun of October 9, 1893.

The annular eclipse of the Sun, which occurs on October 9, 1893, will be visible as a partial eclipse throughout the western and south-western half of North America and on the western coast of South America. It will not be visible at points east of Denver and north of Florida. The path of the annulus will lie almost wholly in the Pacific Ocean, touching land only in the vicinity of Lima, Peru. The eclipse will have very little scientific value, and astronomers will confine their observations to noting the two times of contact and any accompanying phenomena.

At Mt. Hamilton the eclipse will begin at $10^h\ 21^m\ 36^s$ A. M., Pacific standard time, at $10°\ 47'$ north of the Sun's west point, and end at $12^h\ 56^m\ 33^s$ P. M., at $12°\ 41'$ east of the Sun's south point. There is an unavoidable uncertainty of several seconds in the predicted times.

At San Francisco the contacts occur about a minute earlier than at Mt. Hamilton. Similarly, for points east and south-east of Mt. Hamilton the contacts occur later. At the time of greatest eclipse the Moon will obscure the south-western half of the Sun, for observers in California. W. W. Campbell.

## Brilliant Meteors, August 30–31, 1893.

Sonoma, August 31.—Sonoma valley residents were treated to an unusual sight last night about 11 o'clock, when a bright meteor appeared in the eastern part of the sky. It resembled the flash of an electric light and lit up the town like day. It appeared to be only a few hundred feet from the earth.

San Andreas, August 31.—Last night at 10:50 o'clock there appeared one of the most brilliant meteors ever seen in this section. It exploded a short distance northwest of the town, lighting up the whole heavens as bright as day. It seemed to emanate from the constellation *Cassiopea*, and coursed in a nearly northwest direction.

Ukiah, August 31. At about 2 o'clock this morning the eastern sky was illuminated by the fall of an exceedingly brilliant meteor. This privateer of the heavens fell apparently about three miles from Ukiah. As it struck the earth it exploded with a sound similar to the discharge of an immense sky rocket.

The supposed scene of the fall of the meteor was visited by hundreds to-day, but no indication of the presence of the celestial visitor was discovered. —S. F. *Chronicle.*

### THE BRUCE TELESCOPE.*

CAMBRIDGE, Aug. 19.—The conditions have not been good for making practical tests with the BRUCE photographic telescope since its completion early in the week, but the tests thus far have proved very satisfactory. The telescope has a focal length of 11 feet 3 inches, and an objective of about 24 inches. There are four lenses, made of flint and crown glass imported from Paris. The front lens is 3¼ inches thick in the center and ⅞ inch at the edge. The front flint glass measures three-fourths of an inch in the center and 2.35 inches at the edge. The crown lens in front weighs 93 pounds and the flint lens 91 pounds. The back flint lens measures eight-tenths of an inch in the center and 2 inches on the edge. This weighs 80½ pounds. The back crown lens measures 2¼ inches in the center and .67 inch at the edge. There is a separation of 2¾ inches between the lenses. The prism used in this telescope is made of flint glass, and is 25 inches in diameter. The thick edge is 2.88 inches and the thin edge nine-tenths inch. It weighs 125 pounds.

This telescope will photograph stars of the seventeenth magnitude or greater. Mr. CLARK is at work upon another big telescope, which it is thought will surpass even the BRUCE telescope. This has been provided by Mr. YERKES of Chicago, and is intended for the new observatory which is to be erected in connection with the Chicago University. It will have a focus of 63 feet. The flint glass lenses to be used weigh 310 pounds and the crown lenses 205 pounds.—New York *Sun*, 1893, August 20.

### VISITORS TO THE LICK OBSERVATORY.

The visitors' books of the Observatory show :

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 6400 | Visitors | admitted | for the | Year | ending | June | 1, 1889 |
| 5132 | " | " | " | " | " | " | 1, 1890 |
| 5005 | " | " | " | " | " | " | 1, 1891 |
| 5959 | " | " | " | " | " | " | 1, 1892 |
| 5472 | " | " | " | " | " | " | 1, 1893 |
| 27968 | " | " | for the Years 1888–1893. | | | | |

About ten per cent. of the visitors do not register.

E. S. H.

* See these *Publications*, Vol. V, page 82.

## Minutes of the Meetings of the Board of Directors, held in San Francisco, August 14, and at the Lick Observatory, September 9, 1893.

At a special meeting of the Board of Directors, held in San Francisco on August 14, 1893, it was *Resolved*, That the September meeting, to be held at the Lick Observatory, be postponed to September 9.

Adjourned.

Professor Campbell took the chair, and a quorum was present. The minutes of the last meeting were approved. The following members were elected:

List of Members Elected September 9, 1893.*

| | |
|---|---|
| J. J. Aubertin* | 33 Duke Street, St. James, S. W., London, England. |
| Loyal H. Bradford | North Ferrisburgh, Vermont. |
| Arthur Collins | Swarthmore, Delaware Co., Pa. |
| Henry Cowell* | 413 Hyde Street, S. F. |
| Walter F. Gale, F. R. A. S. | Paddington, Sydney, N. S. W. |
| Jos. F. Gassmann | 318 Montgomery Street, S. F. |
| S. D. José Gonzalez | Observatory, Bogota, U. S. of Columbia, South America. |
| Paul Tycho Johnson | Livermore, Alameda Co., Cal. |
| Edward Lande | Mills Building, S. F. |
| Clarence Mackenzie Lewis | 104 E. 37th Street, New York, N. Y. |
| M. M. Parker | San José, Cal. |
| Miss Mary A. Sullivan | 571 36th Street, Oakland, Cal. |
| R. H. Tucker, Jr. | Lick Observatory, Mt. Hamilton, Cal. |

It was *Resolved*, That Professor Hussey be authorized to expend, not to exceed $30 in providing illustrations to be made from his negatives of Comet *b*, 1893, made at the Lick Observatory.

Adjourned.

## Minutes of the Meeting of the Astronomical Society of the Pacific,* held at the Lick Observatory, September 9, 1893.

Professor Campbell presided. The minutes of the last meeting as printed in the *Publications*, were approved. The Secretary read the names of members duly elected at the meeting of the Directors.

* A star signifies life membership.

The following papers were presented:

1. Preliminary Note on the Corona of April 16, 1893, by Professor J. M. SCHAEBERLE.
2. The Spectrum of Comet *b*, 1893, by Professor W. W. CAMPBELL.
3. Photographs of Comet *b*, 1893, made at the LICK Observatory, by Professor W. J. HUSSEY.
4. A Summary of the History of the New Star of 1892, by Professor E. S. HOLDEN.
5. Comparison of the New Star Spectrum with the Spectra of Five well-known Nebulæ, by Professor W. W. CAMPBELL.
6. Predictions of the Times of Beginning and Ending of the Solar Eclipse of October 9, 1893:

   For Various Places in the State of Washington, by O. E. HARMON.

   For Mount Hamilton (and San Francisco), by Professor W. W. CAMPBELL.
7. The *Cordoba Durchmusterung*, by R. H. TUCKER, Jr.

Nos. 1, 5 and 7 were read and discussed.

Adjourned.

## OFFICERS OF THE SOCIETY.



## OFFICERS OF THE CHICAGO SECTION.



## OFFICERS OF THE MEXICAN SECTION.



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## NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book-keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend any or all of the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

THE 40-INCH TELESCOPE OF THE YERKES OBSERVATORY OF THE UNIVERSITY OF CHICAGO.

*Objective by Alvan G. Clark; mounting by Warner & Swasey.*

[From *Astronomy and Astro-Physics*.]

PUBLICATIONS

OF THE

# Astronomical Society of the Pacific.

VOL. V. SAN FRANCISCO, CALIFORNIA, NOVEMBER 25, 1893. NO. 32.

## VARIATION OF LATITUDE.*

BY W. J. HUSSEY.

The ordinary work of an engineer does not usually require him to take account of forces producing minute effects nor of quantities which are extremely small. Such forces and quantities are generally negligible when their magnitudes are small as compared with the uncertainties in the magnitudes of the other forces and quantities with which they are to be compared. In engineering structures the qualities of the materials employed and the friction of stationary and moving parts are ordinarily sources of quantities which are variable between wide limits and more or less indeterminate in their amounts. When this is the case, it is quite unnecessary to use a rigorous theoretical treatment or a refined practical application, so far as these uncertainties are concerned. But the engineer's work is not all of this character. Some of it requires rigorous treatment in theory and practice. When such is the case it is necessary to know and take account of all the influences which measurably affect the accuracy of the results. Numerous examples illustrating this might be cited. It is proper to mention here some of those belonging in common to the engineer and to the astronomer. It is so in geodetic work and in the determinations of meridians and important boundaries. These require a very high grade of engineering work combined with an equally high grade of astronomical work. In these cases the astronomical part consists largely in determining azimuths, longitudes and latitudes as accurately as possible. Each of these presents singularities peculiar to itself, and in the case of latitude

* Reprinted from *The Technic*, 1893.

the chief singularities relate to its variation. In the following paragraphs this subject will be briefly considered.

Before considering the phenomenon of the variation of latitude, as it appears from observation, it will be well to give, even at the risk of being somewhat technical, a few of the results which follow from the dynamical principles involved in the case of rotating bodies and then to see what the applications of these results are in the case of the Earth. For the present it will be assumed that the rotating body is perfectly rigid.

For any point of a rigid body there are three principal axes and three principal moments of inertia corresponding to them. A body rotating about a principal axis will preserve that axis as a permanent axis of rotation so long as the body is subject to the action of no disturbing force. A disturbing force will, however, change the position of the axis of rotation of the body. The amount of change will depend upon the degree of stability of the principal axis and upon the magnitude of the disturbing force. In case the rotation is *stable*, a small force will, at most, only cause a small deviation of the axis of rotation from a fixed straight line known as the invariable line. If, however, a small force eventually produces a very great change in the rotation, it is *unstable*. So far as has been, and, probably, can be determined, the rotation of the Earth is stable, and the actual deviation of the axis of rotation from the invariable line is very slight indeed. Still it is large enough to have a measurable influence on the results of astronomical observation, and as it is one of the chief causes of the periodic variation of latitude, we will proceed further with the results obtained from dynamical considerations.

When the rotation of a rigid body does not take place about a principal axis, the axis of rotation does not remain fixed in the body, but continually changes its position, even though the rotation is not disturbed by the action of any extraneous force. The line through the body coincident with the axis of rotation at any instant is at that instant the instantaneous axis of rotation. The movement of the instantaneous axis of rotation can in some cases be determined. The case of interest to us is that in which two of the principal moments of inertia about the center of gravity are equal and each nearly the same as the third one, and in which the axis of rotation is nearly though not quite in coincidence with the unequal principal axis. And for our case we may further assume that the rotation is not disturbed by the action of any ex-

traneous force. Under these conditions the invariable line and the instantaneous axis of rotation both move with reference to the body. They describe in it co-axial right cones, the common axis of which is the axis of unequal movement of the body. But the invariable line is fixed in space and consequently the axis of unequal moment really describes a right cone about it, and so also does the instantaneous axis of rotation. The semi-angles of the cones described about the axis of unequal moment by the invariable line and the instantaneous axis are connected with each other and with the principal moments of inertia by a very simple relation, from which, in the case of the Earth, it can be shown that these semi-angles are very nearly equal. The relation is

$$B \tan \alpha = A \tan \beta,$$

where $\alpha$ and $\beta$ are respectively the angles made by the invariable line and the instantaneous axis of rotation with the axis of unequal moment and $B$ the unequal and $A$ one of the equal moments of inertia. Then $\alpha$ and $\beta$ are the semi-angles of the co-axial cones and their difference the semi-angle of the cone described by the instantaneous axis about the invariable line.

The Earth is not exactly a spheroid of revolution, but it is so nearly so that this assumption will not lead to appreciable error. It is not a thoroughly rigid body, but in order to apply the above results it will, for the moment, be regarded as such. These conditions give two equal principal moments of inertia. Moreover, the rotation as assumed above is very approximately satisfied by it. The attractions of the Sun, Moon and planets do not act, as might at first be supposed, as forces disturbing that part of the motion now under consideration. Hence they do not invalidate the results given. They produce precession and nutation and although the effect now being considered is known as the Eulerian nutation, it really comes about by making an abstraction of the disturbing forces and regarding the Earth as simply set in rotation and left to itself. It is that part of the motion, analytically considered, which is derived from the complementary functions arising in the integration of the differential equations obtained in taking account of the action of the Sun and Moon in disturbing the rotation of the Earth. To obtain these complementary functions certain terms must be placed equal to zero, and this happens to be equivalent to making an abstraction of all extraneous forces. According to theory, then, the instantaneous axis

of rotation and the invariable line describe co-axial right cones in the Earth, of which the common axis is the axis of figure. And the rotation axis describes a right cone in space about the invariable line as an axis. Theory further shows that the axis of rotation will revolve about that of figure from west to east and in a period of

$$\frac{\sin \beta}{\sin (\alpha - \beta)}$$

days. In order to determine this theoretical period, $\alpha$ and $\beta$ must be known, or, at least, since they are small and nearly equal, the ratio of either to their difference must be known. It can be shown, still assuming the Earth to be perfectly rigid, that this ratio cannot exceed 306 times either and that this is its approximate value. Hence, the theoretical period is about 306 days or about ten months. This is often referred to as "EULER'S ten-month period."

Such, in short and in part, is the theory of the rotation of the Earth as accepted until recently. But theory is not always correct and that it has not been so in this case has been demonstrated by Dr. CHANDLER in his recent important researches on the variation of latitude. And Professor NEWCOMB has pointed out a defect in the theory: it is in not taking account of the want of rigidity of the Earth and in wholly neglecting the fluidity of the oceans which surround it. These are important elements. Their effect is to lengthen the theoretical period of the revolution of the axis of rotation about that of figure. Thus, by assuming the Earth to be homogeneous and to have a rigidity equal to that of steel, a period of 441 days is obtained instead of 306 as required by a perfectly rigid Earth.

Latitude, as found by observation, is the complement of the angle included between a vertical line through the place of observation and the instantaneous axis. The vertical line is determined by the direction of gravity which may be assumed to be constant so long as the form of the Earth and the distribution of the materials composing it remain the same. From this it is evident that there will be a variation of latitude if the axis of rotation is not a fixed line in the Earth and that this variation will be periodic if the axis of rotation revolves regularly about that of figure. And it is further evident that the amplitude of variation will depend upon the angular separation of the two axes and that the phases

of variation will progressively move around the Earth. Places differing in longitude will, at any given time, exhibit different phases.

It has long been known that if such periodic variations exist and are of measurable magnitudes, they will afford the means of determining the position of the axis of rotation with reference to that of figure. Analytically considered, this requires, simply, the determination of the values of two constants of integration. By means of data furnished by observation attempts were made some years ago to find the values of these constants, with the result that both seemed to be zero, which would indicate a coincidence of the two axes. But such is not the case. Dr. CHANDLER has recently shown that there is a revolution of the axis of rotation from the west to the east in a period of 427 days and that the semi-amplitude of the variation of latitude due to it is about 0.″12. He has also shown that there is another periodic variation, which will be spoken of later on.

That this periodic variation was not previously detected by those who attempted to discover it, PETERS, NYRÉN and others, is probably due to their too strict adherence to theory and to the 306-day period which it indicates. In cases like this where the quantities in question are small and likely to be confused with instrumental and other errors of observation, it cannot be expected that the solution of equations of condition will give results of a confirmatory character unless the assumptions which are involved in their formation approximate closely to the truth. Naturally, then, the use of a period of 306, instead of the true one of 427 days, would lead to inconclusive results. Dr. CHANDLER'S success, aside from the vast amount of painstaking labor which it has required, is due to his having perceived the inadequacy of existing theory to account for the observed phenomenon and to his skill in treating a difficult problem by strictly inductive methods. He tells us that he "deliberately put aside the teachings of theory, because it seemed high time that the facts should be examined by a purely inductive process; that the nugatory results of all attempts to detect the existence of the Eulerian period probably arose from a defect of the theory itself; and that the entangled condition of the whole subject should be examined afresh by processes unfettered by any preconceived notions whatever." And the problem which he proposed to himself was "To see whether it would not be possible to lay the numerous ghosts—in the shape

of various discordant residual phenomena pertaining to the determination of aberration, parallaxes, latitudes and the like—which had heretofore flitted elusively about the astronomy of precision, during the century; or to reduce them to a tangible form, by some simple, consistent hypothesis. It was thought that if this could be done, a study of the nature of the forces, as thus indicated, by which the Earth's rotation is influenced, might lead to a physical explanation of them."

In the course of his investigations, he has searched astronomical records for data bearing on the question and in doing so he has relied not merely on recent observations but has gone as far back as the time when BRADLEY was using his sextant at Wanstead in 1726. For somewhat more than a hundred years from the beginning of this period, the observations do not form a continous series, so that it has not been possible, so far, to trace satisfactorily the course of the variations of latitude which they plainly exhibit. But for the last fifty years the series is fairly continous and this has enabled results of great importance to be obtained. These will be given, but before doing so, it may be well to state that they have been obtained through a discussion of some thirty-three thousand observations, one-third of which were made in the southern hemisphere. Seventeen different observatories participated in making these observations, and four of these observatories belong to the southern hemisphere. In making them twenty-one different instruments and nine different methods of observation have been used.

The first result obtained has already been mentioned, the revolution of the axis of rotation about that of figure in 427 days. This produces a periodic variation of latitude having, as was finally determined, a semi-amplitude of 0."12. By a consideration of the results obtained at widely separated observatories, it was shown that this variation is neither instrumental nor local, but terrestrial, and it led at once to Professor NEWCOMB'S modification of the theory of the Earth's rotation. For a time, during the progress of the investigation, it seemed probable that this variation was subject to a considerable variation both in period and amplitude. But this is not the case. By a rearrangement of the data, the true character of the variations were disclosed and it was seen that this apparent variation is due to the superposition of another periodic variation. The latter has an annual period with its minimum and maximum values just before the vernal and

autumnal equinoxes respectively and its zeros just before the solstices. In amount its variation is not constant, but ranges from $0.''04$ to $0.''20$. The cause of this variation has not yet been ascertained, so that it is not possible to predict with certainty the effects which it may produce in the future. Its variations during the past fifty years are known in a general way. The minimum value of its range was reached some time between 1860 and 1880 and its larger value has prevailed before and since these dates.

The resultant variation of latitude due to these two causes is, of course, their sum. When they are at opposite phases, it may nearly disappear and when they are at the same phase and the annual term at its maximum, it may amount to nearly two-thirds of a second.

A rigorous formula representing the variations can not be given until the cause of the annual variation and its laws have been ascertained. Dr. CHANDLER has given a provisional formula, for the longitude of Greenwich, which closely represents the variations of the past fifty years, and it is probable that it will approximately represent them for a few years to come. In his formula the first term takes account of the variation due to the 427-day period and the second term that due to the annual period. His formula, after making a slight change in it so as to make it applicable at a place whose longitude is $\lambda$, is

$$\phi - \phi_0 = -0''12 \cos\left[\lambda + 0.^\circ 835\,(t - T)\right] - r_2 \cos(\odot + 10^\circ)$$

where $T$ and $r_2$, are computed by means of

$$T = 2406193 + 431\,E,$$
$$r_2 = 0.''047 + 0.''003\,\tau + 0.''00025\,\tau^2$$

and where the meanings of the symbols are as follows: $\phi$ and $\phi_0$ are the instantaneous and mean latitudes of the place; $T$, the date at which the north pole of the Earth's figure passes the meridian of Greenwich; $t$, the date of observation; $\tau$, the interval in years, positive after 1875; $E$, the number of completed revolutions between the date $t$ and the adopted epoch 1875, November 1; and $\odot$ the longitude of the Sun. The interval $(t - T)$ is to be expressed in days. The first member $\phi - \phi_0$ symbolizes the variation of latitude at the time $t$. 1875, November 1 is the 2406193d day since the commencement of the Julian Period. This accounts for that number, it being the adopted epoch of the formula. A

somewhat simpler formula gives a considerably closer representation of the observations from 1862 to 1882. It is, for the meridian of Greenwich,

$$\phi - \phi_0$$
$$= -0.''125 \cos [0.°843 (t - 2406191)] - 0.''050 \cos (\odot + 10°)$$

in which $t$ is the number of days since the beginning of the Julian Period.

From the smallness of these variations it will be seen that the corrections to the latitude which they give will seldom need to be considered. It is only in the most accurate work that their being neglected will have any appreciable influence. As has been stated above, the problem of the variation of latitude is not yet fully solved. The cause of the annual term is yet unexplained. The question of the secular variation of latitude has been raised, but its existence has not yet been established, and even if it is, it is not likely to have any very sensible influence upon the results, either of the engineer or of the astronomer. From an astronomical point of view, the variation of latitude is important not in itself alone but also on account of the influence it has in vitiating the results of the astronomy of precision. It affects almost all kinds of absolute measurements. Equator point, equinoctical point, obliquity of the ecliptic, constant of aberration, stellar parallaxes, and absolute right ascensions and declinations of stars, may be mentioned as examples. And when the systematic errors introduced by it are eliminated, a conclusion is reached which is most gratifying to astronomers. It is that the degree of precision already attained in astronomical observation is far greater than had hitherto been supposed.

STANFORD UNIVERSITY, CALIFORNIA, April 8, 1893.

## THE BRIGHT STREAKS ON THE MOON.

BY J. M. SCHAEBERLE.

The remarkable appearance presented by the Moon's surface, more particularly with reference to the great light-reflecting power of certain peculiarly arranged areas, has given rise to various hypotheses concerning the cause of these features.

As a result of certain investigations at present under way,

a singularly plausible explanation has forced itself upon my attention. As the matter is intimately connected with some results outlined in a "preliminary note" published in No. 306 of the *Astronomical Journal*, I must refer the reader to that journal for explanations relating to certain statements made in the present paper.

For several years past I have repeatedly stated that apparently the space within the solar system is traversed by streams of finely divided matter, ejected from the Sun with very great velocity. The reasons for holding this opinion are, of course, based upon observation.

Volcanic eruptions on the Moon's surface were formerly (if not now) a marked feature of lunar life, judging from the topographical appearance of the Moon and the present condition of the parent body.

During an eruption the local atmosphere of dust particles ejected from the Moon, besides retarding the velocity of a passing coronal stream, will at the same time be carried along with the stream; but owing to the Moon's attraction, the material particles are deposited along an arc of a great circle passing through the point of eruption.

As the Moon rotates on its axis the stream of particles will revolve about the local atmosphere as a center or nucleus. The density of the local stream will depend upon the volcanic activity and the momentum of the coronal stream. Volcanic matter sent to the greatest height will in general be carried to the greatest distance from the origin, which may evidently be as great as a whole circumference of the Moon, and, indeed, may be wholly removed from the Moon's direct influence.

In this way even a single large active volcano on the Moon could supply enough material to render conspicuous all the craterlets and other depressions and elevations acting as obstructions to a uniform distribution of particles along the path of a stream. On the Earth's surface such a distribution could not take place owing to the universal atmosphere overlying the whole surface to a depth of many miles. With us the meteorological elements, especially the prevailing winds, would, for a given case, almost wholly determine the final location of the volcanic dust particles. I have in mind the region of country surrounding Arequipa, to which Professor W. H. PICKERING also calls attention in writing on the same subject in No. 3111 of the *Astrono-*

*mische Nachrichten.* Here hundreds of square miles of territory are rendered conspicuously brilliant by the enormous quantity of fine volcanic sand deposited in the lower places in the mountains to a depth of many feet, while on the plateaus thousands of mounds literally cover the ground, each mound containing many hundred cubic feet of this volcanic dust. These crescent-shaped pyramidal mounds are constantly undergoing a change of position without any considerable change from a typical form, the disturbing force, a slight air current, is made manifest to the observer in the form of delicate streams of sand, apparently issuing from the top of each pyramid, but in reality driven from the slightly convex side to the slightly concave surface of each mound. Viewed from the top of the west peak of Chachani, more than 18,000 feet above the sea, and from 10,000 to 14,000 feet above the immediate surroundings, the irregularities of distant surface features are rendered strikingly plain to the observer, as the lower places are most brilliant owing to the greater light-refracting power of the volcanic sand there accumulated.

This sand is not uniformly distributed or even symmetrically situated with reference to the probable center of discharge; in all other respects I was strongly reminded of the lunar features in the neighborhood of conspicuous craters.

A symmetrical distribution of volcanic sand would naturally be expected around a lunar crater, there being no atmosphere, but the great regularity and almost mathematical directness of the paths, and the enormous distances to which the matter (assuming it to be volcanic dust) is carried—hundreds of miles—calls for the action of another force (extraneous) to account for remarkable observed distribution on the Moon's surface. The same theoretical cause which acts to produce the tail of a comet will evidently, in a precisely similar way, produce a miniature representation of a comet on the Moon's surface.

LICK OBSERVATORY, November 13, 1893.

# THE SOLAR ECLIPSE OF OCTOBER 9, 1893. REPORTS OF OBSERVATIONS.

## OBSERVATIONS AT THE CHABOT OBSERVATORY, BY MR. BURCKHALTER.

"I observed the partial eclipse of October 9, *by projection.* The seeing was fair. I do not consider the method by projection as satisfactory as the direct method.

Contact I. $10^h\ 20^m\ 24^s$, P. S. T., A. M.
II. $12^h\ 55^m\ 0^s$ P. M."

CHARLES BURCKHALTER.

[Dated]
CHABOT OBSERVATORY, October 9, 1893.

## THE SOLAR ECLIPSE OF OCTOBER 9, IN THE STATE OF WASHINGTON.

A note from Mr. O. E. HARMON says that observations of the eclipse were prevented by clouds at his station (Chehalis, Lewis County), and also at the station of Professor TAYLOR. (Observatory of the State University, Seattle).

## MOUNT HAMILTON OBSERVATIONS OF THE LAST CONTACT OF THE PARTIAL SOLAR ECLIPSE OF OCTOBER 9 AND 10, 1893.

The sky was overcast till about noon. The following observation of Contact II were secured:

| OBSERVER. | PAC. STANDARD TIME. | INSTRUMENT. |
|---|---|---|
| | h. m. s. | |
| J. M. SCHAEBERLE | 0 56 31.8 | In focus of 40-foot photoheliograph. |
| E. E. BARNARD | 0 56 29.6 | 12-inch refractor. |
| "Time of *tangency of limbs* at last contact. A large lump was visible one or two seconds longer." | | |
| R. H. TUCKER, JR. | 0 56 32.7 | 4-inch finder of 36-inch telescope. |
| A. L. COLTON | 0 56 21 | 3-inch portable telescope. |
| C. D. PERRINE | 0 56 33 | In focus of 40-foot photoheliograph. |

Professor SCHAEBERLE and Mr. PERRINE secured seven negatives of the last half of the eclipse with the photoheliograph.

# CHARTS OF FAINT STARS FOR MAGNITUDE COMPARISON.

By R. H. Tucker, Jr.

During investigations at the Harvard College Observatory, to fix a scale of Standard Magnitudes, a series of small charts were made to show the reach of the 15-inch telescope of that observatory. The charts were arranged according to the following system: Bright stars were selected near the equator, at intervals of about $1^h$, and the chart was begun at $2^m$ of Right Ascension following the bright star, extending to $6^m$ following; with a width of $5'$ of Declination each side. So that the charts were $4^m$ of Right Ascension in length, and $10'$ of Declination in width.

The original charts contain all stars seen, down to a magnitude estimated as 14th. These were afterwards revised, in part, at the Naval Observatory, with the 26-inch telescope, and more stars added to show the reach of that instrument.

In August of this year I took up some of the charts, with the 36-inch telescope of the Lick Observatory, revising and when necessary correcting the originals, and adding the stars within reach. The magnitudes of such stars as had already been plotted were in general adopted, and the new ones added were estimated on approximately the same scale, some falling well within the limits of that scale, but the greater part being fainter. These fainter stars were estimated as 16th and 17th magnitude. The power used was 350, and while no effort was made to choose especially fine nights, all were good. No star was entered without being distinctly seen and checked; and while it seems probable that from the loss of sensitiveness in the eye, having to turn from the telescope to a working chart, and return to check the place, some of the fainter stars have escaped, I believe the charts will contain all the 16th magnitude, and the greater part of the 17th.

Since it seems sufficient for the purpose to take charts at intervals of two hours, thus always presenting one within easy reach and advantageous position for comparison, I have numbered those selected in accordance with this plan; No. IX having the approximate Right Ascension of $18^h$, and No. XII that of $0^h$.

The accompanying charts follow the stars given below, always

by $2^m$; extending $5'$ each side of the bright star, of which the place for 1893 is entered in the list.

| | | | | |
|---|---|---|---|---|
| IX. | Follows $\eta$ *Serpentis* | $18^h$ $16^m$ | $-$ | $2°$ $56'$ |
| X. | " $\theta$ *Aquilæ* | 20 6 | $-$ | $1°$ $8'$ |
| XI. | " $\alpha$ *Aquarii* | 22 0 | $-$ | $0°$ $50'$ |
| XII. | " $\gamma$ *Pegasi* | 0 8 | $+$ | $14°$ $35'$ |

The scale of magnitudes is given for each two units of the system, the brightest type including, as well, all stars brighter than 8th magnitude.

The faintest type is made up entirely of new stars added with this telescope, but, as already stated, some new ones fall within the limits of brighter types and have been so plotted.

A few stars plotted at Cambridge were not seen at Washington; and a few of those on the charts as obtained by me, were not found here. These were most probably due to some misidentification of the places, since when the region happens to have but few stars there is no good configuration to follow.

These four charts contained 230 stars, after the corrections had been made here and missing stars omitted. The 36-inch telescope adds 491 to the same regions, 470 of which are estimated as 16th and 17th magnitude.

The total number plotted on the four charts is 721.

The stars on the charts fall into the following five grades, according to the numbers given below:

| | |
|---|---|
| 8 and 9 | 7 |
| 10 " 11 | 34 |
| 12 " 13 | 87 |
| 14 " 15 | 123 |
| 16 " 17 | 470 |

The numbers show a large proportion of the fainter type, and it is probable that more of the new stars added should be included in the next grade above, 14 and 15.

These charts may serve to show the reach of photographic plates, and it can safely be predicted that those containing all stars of the charts will include the 17th magnitude.

R. H. TUCKER, JR.

LICK OBSERVATORY, November 6, 1893.

## DISCOVERY OF COMET *b*, 1893.

Notes on the independent discovery of this comet by Messrs. RORDAME, QUÉNISSET, MILLER, JOHNSON, ROSO DE LUNA, SPERRA, have been printed in these *Publications*, 1893, pages 154-5. A full account of Mr. SPERRA'S observations is given in *Astronomy and Astro-Physics*, 1893, page 757. The Committee on the Comet-Medal, having carefully considered the case, and having asked the advice of the editors of the leading astronomical journals, has adopted the following resolutions:

**I. That a copy of the Comet-Medal shall be struck, having the *obverse* as usual and the *reverse* blank, and that on the reverse of this copy shall be engraved the words:**

***To Commemorate the Discovery of Comet* b, *1893*.**

**II. That this Medal shall be preserved in the cabinet of the Astronomical Society of the Pacific, and no award made for the discovery of this comet.**

**III. That a copy of No. 32 of the Society's *Publications* shall be sent to each of the gentlemen named above.**

Committee on the Comet-Medal.

EDWARD S. HOLDEN,
J. M. SCHAEBERLE,
CHAS. BURCKHALTER.

[Dated]
December 1, 1893.

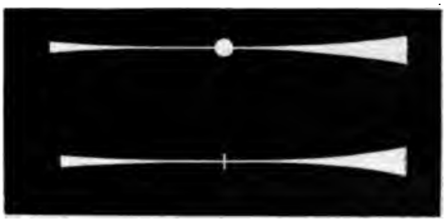
## HYDROGEN ENVELOPE OF THE STAR DM. $+30°$,3639.

By W. W. CAMPBELL.

One of the theories advanced to account for the presence of bright lines in stellar spectra is that such stars are surrounded by unusually extensive and luminous atmospheres. Though this theory is far from being generally accepted, it must be considered as a perfectly natural one, for the reason that it is practically identical with the accepted theory of nebulæ and their bright line spectra. A large number of the bright line stars have been carefully examined with the 36-inch equatorial and other powerful telescopes for the purpose of detecting possible gaseous envelopes,

but without success. I have just found, by a spectroscopic method, that the 9.5 magnitude star DM. +30°, 3639 is surrounded by an extensive hydrogen envelope. This star is of the WOLF-RAYET type; and is very rich in bright lines, about thirty having been accurately located. Besides the continuous spectrum, the most striking features of this spectrum are a bright line in the yellow at wave-length 5694, the bright hydrogen $H\beta$ line and a bright blue band at 4652.

Now when the spectroscope is adjusted for the different parts of the spectrum the line at 5694 reduces to a star-like point of light; the blue band is quite broad, but short, and lies wholly on the continuous spectrum; while the $H\beta$ line is a bright disc at least 5″ in diameter when the slit of the spectroscope is open wide, and a fine bright line extending a considerable distance each side of the continuous spectrum when the slit is narrow. The illustration below shows the appearance of the spectrum in the vicinity of $H\beta$, first with open slit and second with narrow slit.



I have examined all the other WOLF-RAYET stars visible here, but have found no certain evidence of the existence of other discs.

It is possible that the disc of DM. +30°, 3639 is of appreciable size on account of the comparative nearness of that star, and observations for investigating its parallax are in progress. If the parallax should prove to be inappreciable, the actual dimensions of the 5″ disc must be comparable with those of many of the planetary nebulæ.

October, 1893.

# NOTE ON THE VISIBLE SPECTRUM OF THE GREAT NEBULA OF ORION.

By W. W. Campbell.

It has heretofore been considered that the visible spectrum of the *Great Nebula of Orion* is fundamentally the same for all parts of the nebula. My observations lead to a very different conclusion, for I find that the relative intensities of the three lines at wave-lengths 5007, 4959 and 4862, which constitute nearly the whole of the visible spectrum, vary within wide limits as the slit of the spectroscope is moved over the different parts of the nebula. The brightest part of the nebula is that in the vicinity of the *Trapezium*, for which the spectral lines have, approximately, the relative brightness 4:1:1. But many of the regions of medium brightness give a spectrum in which the first and third lines are about equally intense; while for many of the faint portions on the south and west borders of the nebula the third line is brighter than the first. The isolated portion northeast of the *Trapezium* surrounding the star *Bond*, No. 734, yields a spectrum in which the third line is at least five times as intense as the first. It happens in many regions that of two adjacent parts in the slit at the same time, the first line is stronger than the third for one part, and the third is stronger than the first for the other part.

The ratio of the intensities of the first and second lines appears to remain practically constant at 4:1. The second line is much fainter than the third in nearly all parts of the nebula.

In general the hydrogen line $H\beta$ (4862) is relatively very strong in the faint outlying regions. It is relatively stronger even in the bright region around the *Trapezium* than in any other nebula I have examined, except possibly the planetary nebula SD. — 12° 1172.

October, 1893.

# THE PLANETARY NEBULA SD. — 12°, 1172.

BY W. W. CAMPBELL.

This nebula was discovered by Mrs. FLEMING on the Harvard College Observatory plates by means of its spectrum of bright lines, and attention was called to the fact that its $H\beta$ hydrogen line is unusually bright.

It is a beautiful object as seen in the 36-inch telescope, consisting of a 9th magnitude star surrounded by a circular disc of blue light nearly 15″ in diameter. In the spectroscope, with open slit, the well-known nebular lines at wave-lengths 5007, 4959 and 4862 are seen as circular discs, of which the last is considerably the largest in diameter. The diameters of the three discs were measured with the micrometer, and found to be about 11″, 9″ and 14″ respectively. The relative intensities of the light in the three discs were estimated at 10:3:7. A wedge photometer of increasing darkness was moved over the eye-piece at right angles to the line joining the three discs; and the fact that the disc at 4862 disappeared before the disc at 5007 did, proves that the latter is the brighter. All of the discs are brightest at the centers and fade away gradually as the edges are approached, as would be expected; but the hydrogen disc 4862 is of much more uniform brightness throughout than the other two.

The relative diameters and intensities of these discs are very important, in that they make it almost absolutely certain that the incandescent hydrogen which furnishes the disc 4862 forms the outer shell or layer of this nebula, and that the unknown gases which furnish the discs 5007 and 4959 must for the most part lie within the hydrogen exterior.

It should be pointed out that this nebula is very near the nebulous regions of *Orion*. The hydrogen lines are relatively very strong in the *Orion* nebula spectrum, also, and a possible common origin of the two objects is suggested.

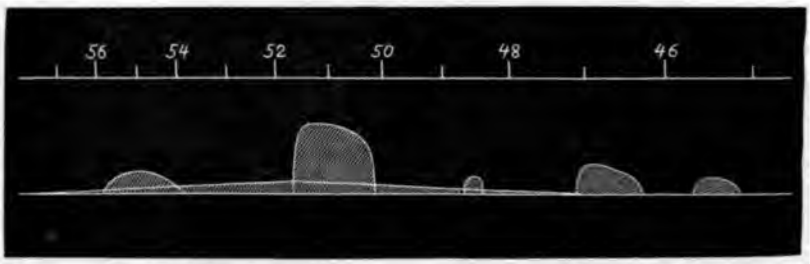
The other hydrogen lines $H\gamma$, $H\delta$ and $H\alpha$ are visible in this spectrum, but the last two are very difficult. No other lines were seen with certainty.

November 3, 1893.

# VISIBLE SPECTRUM OF COMET *c*, 1893 (BROOKS).

By W. W. Campbell.

The spectrum of this comet possesses several peculiarities, which can be most satisfactorily explained by means of the accompanying intensity curve:




The horizontal line in the figure is the line of reference. The long flat curve just above it represents the narrow continuous spectrum of the comet's nucleus, yielded, largely at least, by reflected sunlight; and the distance of any point in that curve from the reference line represents the intensity of the continuous spectrum at that point. Similarly, the short and sharply curved lines represent the bright bands which cross the continuous spectrum at right angles and extend a very considerable distance from each side of it. The bright bands are yielded by the incandescent gases which surround the nucleus and form the head of the comet.

The yellow band at wave-length 554, the green band at 515 and the blue band at 470 are the three hydrocarbon bands seen in nearly all comets. The first one of these bands presents its usual appearance; but the second and third bands are narrower, and very much more sharply limited on their violet sides than I have seen them in any other comet. Indeed, both edges of these two bands are equally sharp and straight, and the edges towards the red are not much brighter than the edges towards the violet.

There is also a line or narrow band near 487, and another band near 455, as shown in the intensity curve, and both edges of these bands are straight.

In 1871 Harkness* observed a very faint band at 455 in

* *Washington Observations* for 1870, Appendix II.

ENCKE'S comet, which is possibly identical with that in the present comet. In 1879 VON KONKOLY* observed a faint band in BRORSEN'S comet at wave-length 4823; and in the same comet CHRISTIE and MAUNDER† observed the same band to be "in the neighborhood of the blue band of alcohol at wave-length 4835." However, at about the same time, COPELAND and LOHSE‡ observed the brightest part of the blue band in that comet to be at 4696. It is scarcely possible that the band in BRORSEN'S comet is the same as that at 487 in the present comet. In no other cases, so far as I know, have bands been seen in the vicinity of 487 and 455. Further, I believe that in previous spectra only one band at a time has been observed visually§ in the region 487 to 455, which in the present spectrum contains three.

H. W. VOGEL'S photograph of the cyanogen flame|| shows a strong group of lines in the vicinity of 456. I think it very probable that they account for the origin of the comet band 455.

The band at 487 is too faint to observe except with a wide slit; but it is of nearly uniform brightness, and appears to be no wider than the slit opening. It is probably a line rather than a band, and the nearness of it to the hydrogen $H\beta$ line at 4862 suggests that the line may be due to hydrogen in the comet. This view is further supported by the fact that none of the recent investigations of the spectra of carbon compounds appear to locate a line in that place. But it must not be considered that the presence of free hydrogen in this comet is established.

The table below contains the measures made upon the brightest places in the bands. The results for the first two nights are only

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* *Astronomische Nachrichten*, Vol. 95, pp. 193-96.

† *Monthly Notices R. A. S.*, Vol. 39, pp. 428-30.

‡ *Monthly Notices R. A. S*, Vol. 39, p. 430.

§ In Comet *Wells*, 1882, Dr. Huggins photographed broad lines near 4600 and 4700.

|| *Sitzungsberichte der Akad. Wiss.*, *Berlin*, 1888, p. 526.

**roughly approximate, having been obtained just as daylight was coming on.**

| October 17. | October 18. | October 25. | November 2. |
|---|---|---|---|
| Yellow band | Yellow band | Yellow band | 554 |
| Green band | Green band | Green band | 515 |
| 488 | 488 | 4864 | 4862 |
| Blue band | Blue band | Blue band | 470 |
| 45 | 455 | 455 | 4557 |

**November 3, 1893.**

## PRELIMINARY NOTE ON A MECHANICAL THEORY OF COMETS.

By J. M. Schaeberle.

In my paper on "A Mechanical Theory of the Corona" written three years ago, the concluding paragraph begins as follows:

"The hypothesis, favored by some astronomers, that the matter now revolving about the Sun in cometary orbits was once ejected from the Sun is, according to the Mechanical Theory, rendered extremely probable, and it would not be difficult to bring forward many strong arguments to support this view, and to account for many apparent changes of form in cometary matter."

Lately, various data (especially those given by my large coronal photographs of the last eclipse) have become available, the character of which is such that no apology is needed for presenting my views on the nature of comets at this time, especially as this new theory of comets is a strictly logical consequence of the mechanical theory of the corona.

Direct observations of the Sun's immediate surroundings demonstrate the presence of masses of matter ejected from the Sun with very great velocity. That this matter is not of a uniform density seems to be plainly proved by the evidence of the eclipse photographs. The prominences, for instance, rise to certain limiting heights, corresponding to certain definite initial velocities

of motion. The coronal streams, on the other hand, rise to indefinite heights, and must therefore have, in general, much greater initial velocities.

Any given eruption doubtless gives rise to both prominences and streams. As the ejective force may be assumed common to both, the mass of a given volume of a coronal stream must be less than that of a prominence, and this evidence is given by all eclipse photographs showing both forms.

Now let $v$ denote the velocity of a portion of a prominence whose mass to a given volume is $m$, and let $v'$ denote the velocity of a portion of a coronal stream whose mass for the same volume is $m'$, then for the same ejective force $F$ we shall have, if atmospheric resistances are zero,

$$F = m\,v^2 = m'\,v'^2$$

or,

$$v' = v\sqrt{\frac{m}{m'}},$$

The individual particles going to make up the mass $m$, for example, will not necessarily have equal masses; but, on account of their proximity to each other, all are constrained to have a common velocity $v$. Similarly all the particles in the mass $m'$ are forced to move with the common velocity $v'$.

If now we assume the mean density of a coronal stream to be even as great as one-seventh of that of an accompanying prominence, the same explosive force which during the last eclipse sent prominence matter to a height of 80,000 miles, will send coronal matter forming the streams to an infinite distance.

Each eruption, then, is sending out minute particles of matter with great velocity, and the solid angle of the conical surface inclosing them all may evidently be quite large. Aside from gravitational influences these particles suffer no resistance to motion in space, except where they come into contact with other particles of matter moving in vacuo.

If each particle moves along a normal to the Sun's surface, the density at any given point of a stream will vary inversely as the square of the distance from the Sun's center, and inversely as the velocity; but, as the velocity varies inversely as the square root of the distance, the density must vary inversely as the cube of the square root of the distance from the Sun's center.

In the following table the velocities and corresponding densities of a stream have been computed for various distances from

the Sun, assuming an initial parabolic velocity. The density near the Sun's surface is placed equal to unity. The unit of distance is the Earth's mean distance from the Sun.

| Distance. | Velocity in miles per sec. | Density. | Distance. | Velocity in miles per sec. | Density. |
|---|---|---|---|---|---|
| 0.005 | 370 | 0.936 | 0.10 | 82.7 | 0.0100 |
| .006 | 338 | .712 | .20 | 58.5 | .0037 |
| .007 | 313 | .565 | .30 | 47.8 | .0020 |
| .008 | 292 | .462 | .40 | 41.4 | .0013 |
| .009 | 276 | .387 | .50 | 37.0 | .0009 |
| | | | .60 | 33.8 | .0007 |
| .01 | 262 | .331 | .70 | 31.3 | .0006 |
| .02 | 185 | .117 | .80 | 29.2 | .0005 |
| .03 | 151 | .064 | .90 | 27.6 | .0004 |
| .04 | 131 | .041 | | | |
| .05 | 117 | .030 | 1.0 | 26.2 | .00030 |
| .06 | 107 | .023 | 2.0 | 18.5 | .00012 |
| .07 | 99 | .018 | 3.0 | 15.1 | .00006 |
| .08 | 92 | .015 | 4.0 | 13.1 | .00004 |
| .09 | 87 | .012 | 5.0 | 11.7 | .00003 |
| 0.10 | 83 | 0.010 | 6.0 | 10.7 | 0.00002 |

The above densities refer to streams having a parabolic velocity for which the density becomes zero when the distance is infinite. I find, however, that for a certain limiting elliptical velocity (limiting only because of the Sun's rotation) the density at first decreases with the distance, then a gradual increase takes place until the densest portion of the whole stream is at the point where the velocity is least. Additional evidence that the coronal matter visible during the last eclipse was in rapid motion, is to be found in the observed fact that the curved returning coronal streams shown on my large photographs are apparently most dense in the higher regions. The same is true of the distribution of the prominence matter.

With the foregoing principles as a basis, I now come to a new theory of comets which has for its foundation only the simple action of purely mechanical forces, and entirely independent of those occult forces—electricity and magnetism.

As I shall treat the subject from a purely theoretical standpoint, all the statements and deductions here given refer to a theoretical comet produced by the theoretical causes named.

1. A comet (theoretical) is a large meteor whose composition is of such a nature that certain (or all) of its constituents are evaporated at comparatively low temperatures. The atmosphere

thus formed will, on account of the small mass, always be most dense on the side where the evaporation is most rapid. When the evaporation ceases, this atmosphere will tend to arrange itself symmetrically with reference to the nucleus so long as no other material bodies come into contact with it. Tidal effects will always have a tendency to cause greater or less dissymmetry of form.

2. An increase of temperature, brought about both by a diminishing distance from the Sun and by collisions with minute material particles in space, will be accompanied by a corresponding increase in the mass of the surrounding atmosphere, due both to a more rapid evaporation from the nucleus and to a temporary or permanent capture of the colliding particles.

3. The attraction which the nucleus exerts upon its atmosphere is so extremely small that each of the more distant particles of this atmosphere can be considered as describing an independent orbit, the mean of the separate orbits thus described practically coinciding with that of the nucleus. When the meteorite is very near the Sun the evaporation on the Sun side of the nucleus will be very rapid, which combined with tidal influences may result in the rupture of the nucleus.

4. The tail of a comet (theoretical) is produced both by the visible particles of matter originally forming the comet's atmosphere, and by the previously invisible particles of a coronal stream which, moving with great velocity, finally produce by repeated impact of the successive particles almost the same motions in the visible atmosphere of the comet as would be communicated by a continuously accelerating force directed away from the Sun. The actions on the particles of the stream result in a diminution of the velocity of the more advanced portions which now become visible through a consequent increase of density. A peculiarity of this mechanical accelerating force is that it becomes zero when the particle repeatedly struck by a succession of other particles finally attains the same finite velocity as the stream of striking bodies.

5. As all the particles of a given coronal stream have the same velocity, the momentum of the heavier sets of particles will be greater than the momentum of those having less mass. Let $m_1$, $m_2$, $m_3 \ldots m_n$ denote the masses of different particles of the

stream which strike the comet's atmosphere; the total momentum at a given instant will be

$$v^2 \Sigma m = v^2 \Sigma m_1 + v^2 \Sigma m_2 + v^2 \Sigma m_n$$

A particle whose mass is $m_1$ will penetrate the atmosphere to a distance $s_1$ before being brought to a state of rest relatively to the nucleus. Similarly the particles whose masses are $m_2$, $m_3 \ldots . m_n$ will penetrate the atmosphere to the respective distances $s_2, s_3, \ldots . s_n$. The resulting strata of increased density of the comet's atmosphere will evidently be nearly concentric, the distances between any two strata $f$ and $t$ being $(s_f - s_t)$.

These strata of increased density will in projection be made manifest in the form of luminous and nearly concentric arcs whose greatest brilliancy will, in general, be near the most advanced part of each stratum, and gradually diminish in brightness as they curve away to form the comet's tail.

6. The coronal matter, owing to its retardation, grows so dense that it also becomes visible, and with the comet's atmosphere, is finally driven into the tail by the repeated bombardment of unretarded following portions of the stream.

It is evident that the resulting velocity of different parts of the comet's tail will depend both upon the mass of each individual striking particle and upon the mass of the particle struck. In general, the coronal particles which have the greatest mass will after collision give the greatest velocity, which is gradually accelerated as above described until the speed again becomes so great that no sensible illumination results from the scattered particles. The nucleus and inner portions of the atmosphere, being the most dense, block the passage of the particles so that the axis of the tail will usually have less matter than the space at some distance from the axis.

To keep this note within proper bounds, further general considerations must be published in another form. A simple inspection of the figures given in the preceding table will at once show how greatly the factor depending upon the distance from the Sun influences the form of a comet in general.

The severest test of any given theory is its ability to account for abnormal deviations from a typical form. Some of the most remarkable will be briefly considered.

Many coronal streams issue from the Sun at considerable angles with the normals; in space, therefore, different streams

will cross each other without sensibly interfering with each other's motions. The atmosphere of a comet, however, when placed at such a crossing, will evidently produce as many different tails to the nucleus as there are crossing streams; the angles between the tails being a function of the velocities of motion and the inclinations of the streams.

There are several cases on record of comets having a tail turned *toward* the sun in addition to the usual appendage. I have examined every case known to me, and find that invariably at the time this phenomenon was observed the comet was *receding* from the Sun with great velocity. *A coronal stream, having a less velocity than that of the receding comet, will under these circumstances cause just such a phenomenon the moment the comet enters the stream.* Evidently the main tail will in no way be sensibly affected, since the tenuity of the two coronal streams (one moving with greater velocity than the comet, and the other with less velocity) is so great that no sensible interdisturbance takes place.

Owing to the orbital motion of the comet, different tails will result when the velocities in the tail (as a whole) at a given distance from the nucleus are largely and abruptly different. The curvature will be greatest for the tail which has the least velocity. If a gradual variation in the velocity results, a gradually broadening tail (in general more curved in projection on one side than on the other) will result.

Rapid variations in the form and brightness of the comet will result from the lateral orbital motion of the comet with respect to the stream, often passing from one stream into another. A comet loses its tail if for a considerable time it passes from a stream of greater (or less) velocity, into space sensibly devoid of coronal matter, or into a stream having the same velocity and direction of motion.

When the velocity of the particles in the more distant portions of the tail is much less than that of the streams, the deviation of the axis of the tail from the produced radius vector of the nucleus will become so great that fresh and unretarded streams can plough their way through (across) these more distant parts of the tail, which may result in a visible phenomenon of a striated or columnar structure (as actually observed by Bond and others, in Donati's comet); the axis of each column being roughly parallel to the direction of these coronal streams.

Sudden and sharply abrupt changes in the direction of a comet's tail at great distances from the nucleus will be caused whenever the tail enters another coronal stream whose direction of motion is considerably inclined to the stream passing through the comet's nucleus.

A natural consequence of such motions of coronal matter is to deprive all bodies, of very small mass of any non-growing atmosphere they may have; and also to fix the limit of distance beyond which a body of great mass cannot retain its atmosphere. In this connection I would again call attention to the fact that the phenomenon of the "Gegenschein" can be quite satisfactorily explained on this hypothesis, and that the results following from the capture of coronal particles by our own atmosphere lead to a plausible explanation of the aurora. [See December, 1889, Eclipse Report, LICK Observatory.]

This paper, as indicated by the title, is but a preliminary note on a theory which will be more completely discussed in the forthcoming "Report on the Eclipse of April 16, 1893."—Reprinted from *The Astronomical Journal*, No. 306.

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## (FOURTEENTH) AWARD OF THE DONOHOE COMET-MEDAL.

The Comet-Medal of the Astronomical Society of the Pacific has been awarded to Professor W. R. BROOKS, of Geneva, New York, for his discovery of an unexpected comet on October 16, 1893.

The Committee on the Comet-Medal,

EDWARD S. HOLDEN,
J. M. SCHAEBERLE,
CHARLES BURCKHALTER.

December 16, 1893.

# NOTICES FROM THE LICK OBSERVATORY.

PREPARED BY MEMBERS OF THE STAFF.

## THE ROTATION OF THE MOON ON ITS AXIS.

[From YOUNG'S *General Astronomy*, 1889, page 154.]

The LICK Observatory regularly receives letters of inquiry relating to the question of the Moon's rotation; and in reply regularly refers the inquirer to YOUNG'S *General Astronomy*, as above. It will probably not be thought a waste of space to reprint the two paragraphs and figures referred to. The essence of the question is contained in the second paragraph—the definition of rotation. E. S. H.

*Fig. 79.*

ROTATION OF THE MOON.

"The moon rotates on its axis once a month, in precisely the same time as that occupied by its revolution around the earth. In the long run it therefore keeps the same side always towards the earth: we see to-day precisely the same face and aspect of the

moon as GALILEO did when he first looked at it with his telescope, and the same will continue to be the case for thousands of years more, if not forever.

It is difficult for some to see why a motion of this sort should be considered a *rotation* of the moon, since it is essentially like the motion of a ball carried on a revolving crank. See *Fig. 79.* Such a ball, they say, '*revolves* around the shaft, but does not *rotate* on its own axis.' It does rotate however. The shaft being vertical and the crank horizontal, suppose that a compass needle

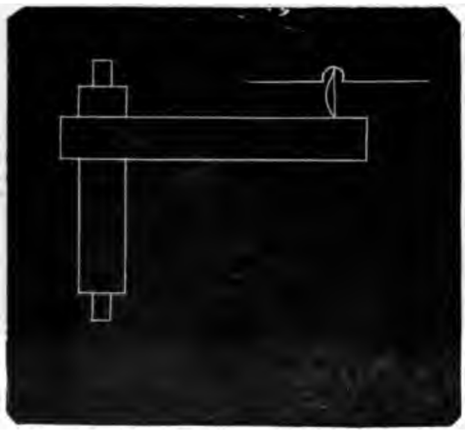

*Fig. 80.*

be substituted for the ball, as in *Fig. 80.* The pivot turns underneath it as the crank whirls, but the compass needle does not rotate, maintaining always its own direction with the marked end north. On the other hand, if we mark one side of the ball (in the preceding figure), we shall find the marked side presented successively to every point of the compass as the crank revolves, so that the ball as really turns on its own axis as if it were whirling upon a pin fastened to a table. The ball has *two* distinct motions by virtue of its connection with the crank: *first*, the motion of translation, which carries its center of gravity, like that of the compass needle, in a circle around the axis of the shaft; *secondly*, an additional motion of rotation around a line drawn through its center of gravity parallel to the shaft.

DEFINITION OF ROTATION.

A body '*rotates*' whenever *a line drawn from its center of gravity outward, through any point selected at random in its mass*,

*describes a circle in the heavens.* In every rotating body, one such line can be so drawn that the circle described by it in the sky becomes infinitely small. This is the *axis* of the body. Another set of points can be found such that lines drawn from the center of gravity outward through *them* describe a great circle in the sky 90° distant from the point pierced by the axis, and these points constitute the *equator* of the body."

## Scientific Visitors to the Lick Observatory.

(Dr. S. P. Langley, Prof. Violle, Colonel Defforges, Mr. Serviss, Doctors Lummer, Kurlbaum, Pringsheim, Lindeck and Wedding.)

During September and early October we have had the pleasure of visits from many astronomers and physicists of distinction. Dr. Langley, Director of the Smithsonian Institution was with us for several days; Colonel Defforges made a determination of the force of gravity here (the fourth dermination: see these *Publications*, Vol. I, p. 125; III, p. 282; IV, p. 266) and was accompanied by Professor Violle; Mr. Serviss, Director of the American *Urania*, Doctors Lindeck and Wedding were here for short times; and Doctors Lummer, Pringsheim and Kurlbaum came as representatives of the *Reichsanstalt.* The Astronomical Congress of Chicago has done the Lick Observatory a great service by sending some of its delegates here for an additional and informal session. E. S. H.

## Stability of the Great Equatorial, 1888-1893.

Observations for the position of the great telescope have been made by Messrs. Schaeberle, Keeler, Campbell and Tucker as below:

1888, July 27, azimuth = + 36″; level = 8″ too low.
1889, May 18, " = . . . . . ; " = 36 " "
Sept. 16, " = + 83 ; " = 58 " "
1890, Aug. 23, " = (+54) ; " = 114 " "
Telescope adjusted.
1891, June 30, azimuth = . . . . . ; level = 35″ too low.
Holding-down bolts tightened.
1892, Aug. 5, azimuth = + 51″; level = 25″ too high.
1893, Sept. 23, " = + 48″; " = 57″ " low.

E. S. H.

BRILLIANT METEORS (SEPTEMBER 30 AND OCTOBER 2, 1893).

HEALDSBURG, September 30.—"A meteor, apparently twice as large as the full moon, passed from east to north at 7:15 o'clock to-night, bursting into fragments above the mountains to the westward. It burned with a green light, leaving a brilliant trail."

WALLA WALLA (Wash.), October 2.—"A meteor of extraordinary brilliancy startled this community at 7:40 this evening, passing from the zenith northward to the horizon. It illuminated the heavens like a blinding flash of lightning. It was preceded by a rushing sound, and divided into two parts just before reaching the horizon."

A USEFUL MAP OF THE MOON.

The most useful map of the Moon for general purposes, which I have seen, especially for quickly finding and identifying lunar formations, is the wall-map of M. C. M. GAUDIBERT, drawn by M. FÉNET and edited by M. FLAMMARION. The craters are numbered on the map and a list on the margin gives their names in the order of the numbers. An alphabetic list of names, giving the number alongside, would be a useful supplement.

The diameter of the Moon is about 25 English inches. The price of the map is $2.50. E. S. H.

THE BRUCE PHOTOGRAPHIC TELESCOPE.

"The BRUCE photographic telescope, which has so long been in process of construction at ALVAN CLARK & SONS', Cambridgeport, will soon be set up at the Cambridge Observatory, and will probably be in operation in the course of a month, says the Boston *Transcript*. Its completion will mark a new epoch in this branch of science, as it is the largest and is thought to be the most powerful instrument of its kind which has yet been set up. The base and operating machinery are already in place at Cambridge, and the tube and lenses, although still at CLARK'S works, are practically completed. It is expected that with this instrument stars can be photographed which have never been seen through the most powerful visual telescopes in the world.

The instrument differs from the ordinary large telescope in the construction of its object lens. The photographic telescopes commonly in use differ but little from an ordinary visual telescope, with an arrangement for the reception of a photographic plate.

This instrument, however, in place of the ordinary lens, composed of two pieces of glass, has a compound lens made of four pieces, which resembles the portrait lens used by photographers. The objective is of 24-inches aperture, and the focal length of the tube is 11 feet. Two smaller instruments constructed on this plan are already in the possession of the Cambridge Observatory, one at Cambridge, and the other in Peru, and have given the greatest satisfaction. They are both of 8-inch aperture, and with them it has been found possible to photograph stars which were not visible through a 15-inch visual telescope. It will therefore be seen that if the new instrument now being constructed should be powerful in the same ratio it will exceed in power a 45-inch telescope of the ordinary kind. As the largest one at present in use is the LICK telescope, which is of 36-inch objective, and the largest anywhere near completion is the great instrument for the University of Chicago, with a 40-inch lens, it is fair to suppose that the BRUCE instrument will photograph stars which can be seen through neither of these. This instrument is superior to the ordinary one, not only in power, but in the extent of sky which can be taken upon a single plate. The ordinary telescope will cover only about 4 degrees at a single exposure, and as there are 40,000 degrees in the whole expanse of the heavens, 10,000 plates would be necessary for a complete report of their whole area. The new telescope will cover six times the area, and will take the whole heavens in 1600 photographs. These photographs, when taken, will not only show many hitherto unknown stars, but will be a valuable and indisputable record of the state of the heavens at the time that they were taken. The whole series could be completed in about a year's time, but it will probably be longer than that before it is finished, as the telescope will be used for other purposes in the meantime.

The building in which the telescope will be placed stands at the back of the main building of the observatory at Cambridge. The base is already in position, as is the fork which is to receive the tube when ready. It looks somewhat like a gigantic tuning-fork slanting upward at a slight angle. Beneath it is the delicate machinery, run by clockwork, which will direct the telescope to any part of the heavens. Near by is a good-sized brick building which has been built specially for the reception and storage of the plates and photographic appliances. On the second floor of this building is the storage-room for the plates. Two large cabinets

run through the center of the room, and are divided into compartments, each capable of holding 100 plates. There are 120 of these compartments, so that each cabinet will hold 12,000 plates. One is devoted to the photographs taken at Cambridge and the other to those taken in Peru. The plates taken by the new instrument will be larger, so that a cabinet with larger compartments has also been prepared, which will hold the result of about a year's work.

The new telescope is the gift of Miss C. W. BRUCE, of New York. It will remain at Cambridge until its capabilities have been thoroughly tested, which will probably be in two or three years, and then will be shipped to its ultimate destination in Peru. Here it will be set up on a hill near Arequipa, where the South American branch of the Harvard Observatory is located.—*Chicago Inter-Ocean*, October 10, 1893.

## MONUMENT TO THE LATE RICHARD ANTHONY PROCTOR.

Mr. PROCTOR died in New York City in 1888, of yellow fever, and was buried in Greenwood Cemetery, in an unmarked grave. Some of his personal friends in New York proposed to mark his tomb in a suitable manner, when Mr. GEORGE W. CHILDS, of Philadelphia, undertook to bear the whole expense of such a memorial. A committee took the matter in charge, and in October, 1893, the monument was erected and suitably dedicated. A brief account of the ceremonies has been printed, and copies can be obtained from Mr. WILLIAM J. BOK, No. 23 Park Row, New York. E. S. H.

## THE CORDOBA *DURCHMUSTERUNG*, $-22°$ TO $-32°$.

"Dr. JOHN THOME, the Director of the Argentine National Observatory, is to be congratulated upon the publication of the Cordoba *Durchmusterung* catalogue, containing the brightness and position of every fixed star, down to the 10th magnitude, comprised in the belt of the heavens between 22° and 32° of South Declination. The results are a continuation of the *Durchmusterungen* of ARGELANDER and SCHOENFELD from their southern limits. In the present volume 179,800 stars are catalogued, but altogether, the places of 340,380 stars have been determined down to $-42°$. The observations for this great catalogue were begun in 1885 and ended early in 1891. They

reach the enormous number of 1,108,600, and were made entirely by Mr. THOME and Mr. R. H. TUCKER. The area over which the observations have extended is 6075° of a great circle, hence the mean density of stars is 56.2 stars per square degree. The corresponding mean density for ARGELANDER (+90° to −2°) is 15.2, and for SCHONFELD (−2° to −23°) 18.5. The density varies considerably, however, in different parts of the sky, and ranges from 70 to 160 stars per square degree in the Milky Way. Mr. THOME says that a series of twelve maps, each embracing $2^h$ of Right Ascension and 20° in Declination, has been constructed upon the scale adopted by ARGELANDER, and will be issued during next year with the second volume of the catalogue, containing stars within the belt from 32° to 42° of South Declination. The construction of these maps, and the preparation of a catalogue like that of which the first part has just reached us, involves an enormous amount of labor. Indeed it is difficult to understand how, amidst the vicissitudes to which an observatory in the Argentine Republic must be subject, and with such a meagre staff as that under Mr. THOME's direction, it has been possible to do so much excellent work."—Extract from *Nature* for August 24, 1893.

A NEW ASTRONOMICAL PERIODICAL *(Popular Astronomy).*

The following is the title page and contents of No. 1 of the new journal issued by Professor PAYNE:

*POPULAR ASTRONOMY.* "By the Word of the Lord were the Heavens Made." A new Astronomical Periodical, designed for Amateurs, Teachers, Students of Astronomy and Popular readers. Plainly worded and untechnical in language. Amply illustrated. Issued monthly except July and September. Subscription price $2.50 in advance; for foreign subscribers 14 shillings.

*Contents for September, 1893.*—Frontispiece (Plate I), The Moon; Constellation Study (introductory), WINSLOW UPTON, 1; The Spectroscope and some of its Applications (illustrated), JAMES E. KEELER, 9; The Moon, WM. W. PAYNE, 16; The Asteroids and their Relation to the Planetary System, DANIEL KIRKWOOD, 19; Concerted Observation of the Aurora, M. A. VEEDER, 22; Jupiter's Comet Family (Plate II), WM. W. PAYNE, 25; Astronomy with a Small Camera, H. C. WILSON,

26; Nebula and Comet Seeking, LEWIS SWIFT, 30; A Lesson on Harvest Moon, ELIZA A. BOWEN, 32; Shooting Stars: How to Observe Them and what They Teach Us, W. F. DENNING, 34; The Face of the Sky, 38; Planet Notes, 39; Planet Tables, 40; Comet Notes, 44; General Notes, 45; Publisher's Notices, 48. WILLIAM W. PAYNE, CHARLOTTE R. WILLARD. Messrs. WM. WESLEY & SON, London, England, sole foreign agents for *Popular Astronomy*.

### COMPARISON STARS TO *EUCHARIS* (181).

The stars following, used for micrometer comparison with *Eucharis* (181), were observed with the meridian circle in October, the mean epoch being 1893.79.

| L. O. No. * | A. R. 1893.0. | Decl. 1893.0 | S. D. | Mag. |
|---|---|---|---|---|
| | h. m. s. | ° ′ ″ | | |
| 221431 | 22 14 8.49 | −18 0 4.1 | 6103 | 8 5 |
| 221655 | 22 16 32.81 | −17 13 31.0 | 6504 | 8.9 |
| 221951 | 22 19 29.13 | −16 43 52.6 | 6080 | 9.5 |

Each star has been given three observations, and the last one was also observed once with bright wire illumination.

R. H. TUCKER, Jr.

### 40-INCH REFRACTOR OF THE YERKES OBSERVATORY.

A cut of this instrument is given in the frontispiece of the present number printed from an electrotype kindly furnished by Professor PAYNE, editor of *Astronomy and Astrophysics*.

The following statistics will be of interest:

"This instrument, exhibited at the World's Fair in the center aisle of the Manufacturers and Liberal Arts Building, is the largest refracting telescope in the world. It is the gift of Mr. CHARLES T. YERKES to the University of Chicago. The column and head, of cast iron, rise to a height of 43 feet, and weigh 50 tons. The polar axis, of steel, is 15 inches in diameter, 13½ feet long, and weighs 3½ tons. The declination axis, also of steel, is 12 inches in diameter, 11½ feet long, and weighs 1½ tons. The tube is of steel, 64 feet long, and 52 inches in diameter at the center, taper-

* See *Publications* A. S. P., Vol. II, page 307.

ing towards the ends; its weight is 6 tons. The driving-clock, weighing 1½ tons, is located in the upper section of the column; it is wound automatically by an electric motor and is controlled by a double conical pendulum; it is geared to the main driving-wheel, 8 feet in diameter, which, when clamped to the polar axis, revolves it, together with the tube and all its accessories, all weighing 20 tons, in exact sidereal time. All quick motions, slow motions, and clamps, both in Declination and Right Ascension, are operated by hand, and also by electric motors controlled by a switchboard placed within easy reach of the astronomer. The assistant astronomer likewise has full control of all motions from the balcony which surrounds the head, and which, together with the clock, is reached by the spiral staircase. The total weight of the telescope is 75 tons." WARNER & SWASEY.

## A NEW STAR IN THE SOUTHERN SKY.

A telegram from the Harvard College Observatory announces that a new star was discovered on October 26 by Mrs. FLEMING (on a photographic plate). Its position is

$$\text{R. A.} = 15^h\ 22^m\ 16^s. \quad \text{Decl.} = -\ 50^\circ\ 14'.$$

Its magnitude was 7.0 on July 10, 1893. Subsequent letters from Professor PICKERING say that 13 plates of this region were taken in the years 1889 to 1893 and that the plate of July 10 is the first one on which the *Nova* appears. "Its spectrum is identical with that of *Nova Aurigæ*." E. S. H.

November 5, 1893.

## GEOLOGICAL AND SOLAR CLIMATES.

Under the above title Dr. MARSDEN MANSON has published a thesis, issued by the University of California, of more than ordinary merit. Geologists tell us that large areas of now densely populated regions of the earth were at one time covered with ice to a depth of many feet. To most scientists the explanations hitherto given, to account for the cause of the so-called *Glacial Epoch*, seem wholly inadequate. Dr. MANSON's treatment of the problem is unique, and to many it will appear quite convincing. We do not hesitate to recommend it for careful study to those interested in astro-geological physics. J. M. S.

## CALIFORNIA MIDWINTER FAIR.

An International Fair is to be held in San Francisco, in the Golden Gate Park, beginning January 1, 1894. The LICK Observatory will make a full exhibit of astronomical pictures and transparencies. It is expected that Harvard College Observatory, the Physical Laboratory of Johns-Hopkins University, etc., will send representative photographs, etc., for exhibition.

We shall be very glad to take charge of the exhibits of Eastern or European observatories which may be consigned to us, and to see that they are suitably displayed. They should be sent to San José, in the care of the LICK Observatory, and they will be forwaıded from here along with our own boxes.

EDWARD S. HOLDEN.

## COMPLETION OF THE NEW DUDLEY OBSERVATORY.

On the 7th of this month invitations were issued for the inspection of the new building and equipment of the DUDLEY Observatory at Albany.

The old location of the institution was unfavorable for astronomical work in several particulars, made so in part by the growth and extension of the city. Situated on the northern boundary, all observations in the south, where the greater part of the work is carried on, were made directly across the longest extent of the city. The myriads of chimneys, both factory and dwelling, not only obscured the air with smoke, but produced great waves of warm air, rising during the early night between the telescope and the sky.

The tracks of the New York Central pass the hill on two sides, having four sets of rails, on which there is the heaviest character of traffic. There seems to be a layer of rock, extending from beneath the old observatory to a point of the railroad, not perhaps the nearest to the building, and which communicated the vibrations produced by trains, with great force.

These were especially noticeable when heavy freight trains were coming down the grade, with brakes locked, a sliding rather than rolling motion. A nadir observation was usually impossible at these times. When the same trains were ascending on the way west, besides the pounding of the wheels of three or

four locomotives at once, there was the dense volume of smoke, unconsumed as forced under heavy draught from the stacks, rolling often into and through the observing rooms.

The location had been of late years most inconvenient for a permanent home for a family. One of the worst quarters of the city had grown up about the foot of the hill, and had at least to be skirted by any one going to the observatory. No perfectly available road had been constructed to the grounds; there were times when a cart could enter, by a long detour from the center of town, but the trails were rarely long enough in repair to be used for carriages.

For the assistants of the observatory, unhampered by ties which are generally considered to make life attractive, aside from professional duties, and being in vigorous health as a rule, it was not so difficult. The walk of from a mile to a mile and a half to find a boarding house was in some respects even beneficial, though in the deep snows of the severe Albany winter or during heavy rains it was not altogether agreeable. The unsheltered walk up the hill, the last part being made easier by slats nailed to the planking before reaching the steps at the top, was not the place to loiter in the hot summer days. It was best to get over it quickly.

The slats and even the planking used to disappear, in part for the use of the neighbors of the quarter I have spoken of, or, in winter, to make way for coasting for their boys. In this last case it was safer to step aside into the snow rather than stand upon one's dignity, to have it carried away with the remains of one's temper by some swiftly descending cutter.

One's best effort can hardly be given unrestrainedly to astronomical work unless the conditions of living shall be an approach at least to those usually met with. Much that made connection with the observatory pleasant in the old days came from the whole-hearted and interested efforts of the Director and his family. They made the work stimulating to the point of overlooking all trifling hardships in comparison with the inner life of the observatory.

One of General MITCHELL'S sons, in giving an account of his father's life, tells of long evenings spent on the high veranda of the observatory dwelling overlooking the valley of the Hudson and the river and hills beyond; since then others have gathered there and waited for the fading of the long summer twilights.

The observatory building, framed by trees on its summit, was impressive in its quiet and unique isolation, so near a great centre of life.

The new observatory is built in an unimproved portion of the City Park, and has nothing within reach that will interfere with good conditions for observing. The neighborhood will be in the future the residence part of the city, but the observatory will always command the needed isolation. It is accessible by electric tram, within easy walking distance, and has improved equipment, of which mention has already been made in this journal.

The change of site has only been accomplished after long effort, deferred more than once when it seemed as if to be realized. The successful establishment of the new DUDLEY is a gain to the science to which it is dedicated and a just reward to the energy and ability which have made it possible.

R. H. T.

## PORTRAIT MEDALLION OF JAMES LICK.

A bronze portrait medallion of JAMES LICK, made by Mr. F. M. WELLS, in 1888, has been sent to the LICK Observatory by the LICK Trustees. It is mounted on the wall of the main vestibule, facing the principal entrance, over a bronze tablet with the inscription:

LICK ASTRONOMICAL DEPARTMENT
OF THE
UNIVERSITY OF CALIFORNIA.

## STAR SPECTRA IN WHICH TWO OR MORE OF THE HYDROGEN LINES ARE BRIGHT.

In *Astronomische Nachrichten*, No. 2963, ESPIN called attention to the fact that the $H\beta$ hydrogen line is very bright in $\phi$ *Persei*. Shortly afterward I examined the spectrum of that star and found $H\alpha$ to be very much brighter than $H\beta$, as it is at present. I supposed the bright $H\alpha$ line was well known, but am unable to find any statement that it has been observed by others.

Professor PICKERING and Mrs. M. FLEMING have announced in various places that the DRAPER Catalogue photographs show the $H\beta$ line to be bright in the stars $\psi$ *Persei*, $\pi$ *Aquarii*, $\kappa$

*Draconis*, *v Cygni*, *v Sagittarii*, *χ Ophiuchi*, and Cord. Genl. Catal. 7191. I have examined the spectra of all these stars, and in every case the Hα hydrogen line is bright and very much easier to observe than the Hβ line. The hydrogen lines in the violet of these stars are probably dark, for the most part; but photographs of the region Hβ to Hδ of some of these stars show peculiarities of considerable interest, and make a detailed investigation desirable. Thus, in *φ Persei* the Hγ and Hδ lines consist each of two narrow bright lines about four tenth-metres apart upon a background but slightly darker than the ordinary continuous spectrum. In *v Cygni* Hβ, Hγ and Hδ consist of narrow bright lines upon broad and nearly dark backgrounds.

Miss A. C. Maury found from the Draper Catalogue plates that Hβ and possibly Hγ in the spectrum of *Pleione* consist each of a narrow bright line on a dark background. The Hα line is bright in this star. Other observers have possibly called attention to that fact, but I am unable to find any such reference.

Qualitative investigations of these spectra cannot be made advantageously by photography with the 36-inch telescope, owing to the large chromatic aberration of the great lenses in the blue and violet. W. W. C.

October 19, 1893.

## Preliminary Determination of the Eccentricity of the Repsold Meridian Circle.

A series of readings was taken upon the east circle, the fixed one, on November 18. The series consists of readings, each 30°, beginning at the nadir setting, through 360°; then reversing the order of settings back to the starting point.

Denoting by $c$, the reading of the circle at microscope H, the correction for eccentricity for each microscope will be represented by the following:

For Micros. H $e = 2''.85 \sin (c + 243° 45')$
" G $e = 2''.85 \sin (c + 153° 45')$
" F $e = 2''.85 \sin (c + 63° 45')$
" E $e = 2''.85 \sin (c + 333° 45')$

The correction for runs was applied to each microscope; and the position of each, with reference to the mean of four, was taken out from the whole series.

Since the change for any one of the four did not much exceed

$0''.1$, this has been neglected in making a comparison of the original readings, with the same corrected for eccentricity. This being done for each microscope, the residuals of the readings upon the same circle divisions under different microscopes give an indication of the errors of division. These are found to be sometimes as large as $0''.6$, and, on the average, $0''.3$.

The error of division for the mean of four microscopes, on the settings used, does not appear to exceed $0''.1$ on the average. The comparison of the undividual readings corrected for eccentricity, gives for the *probable error* of the reading upon a single microscope $\pm\ 0''.25$, which is larger than that usually found in making comparisons by other means. R. H. T., Jr.

### THE DALLMEYER LENS OF THE ECLIPSE EXPEDITION.

In No. 31 of the *A. S. P. Publications*; under the heading, "Acknowledgments," the name of Hon. WM. M. PIERSON should have been included in the list of those who had materially aided the expedition.

Mr. PIERSON'S practical interest in astronomy is well known to Californians. From his private observatory he furnished the expedition with the excellent DALLMEYER lens of 6-inches aperture with which such valuable eclipse negatives were secured. The same lens was also used in several series of observations for determining the photographic absorption of light rays by our atmosphere at the altitude 6600 feet.

A number of long-exposure photographs of interesting celestial objects visible in the southern sky were also secured with Mr. PIERSON'S lens. J. M. S.

### THE OBSERVATORY ON MONT BLANC.

The construction of a small observatory on Mont Blanc for the venerable astronomer, M. JANSSEN, of Meudon, France, a work of very great difficulty and danger, has progressed satisfactorily the past summer. The foundation has been firmly fixed in the snow and ice, and the building is practically enclosed. From a recent publication of the French Academy we learn that M. JANSSEN visited the new observatory in September, and was able to make a spectroscopic observation of great interest. It related to the question of oxygen in the atmosphere of the Sun. One of the most striking features of the

solar spectrum is the B group of absorption lines, near the red end of the spectrum. In addition to the complex head of the group there are thirteen or fourteen double lines whose intensities decrease as the distance of the doublets from the head increases. These lines owe their origin to oxygen absorption; but the question has been, is the absorption due to oxygen in the solar atmosphere or in the Earth's atmosphere. If the latter, then the lines should not be so prominent if observed at a station of great altitude. M. JANSSEN states that at the station, Chamonix, altitude 1050 metres, the thirteenth doublet is seen with great difficulty; at Grands-Mulets (3050 metres) only eleven or twelve doublets can be seen; while at the summit of Mont Blanc only eight can be seen with certainty. The conclusion to be drawn from these observations is that the B group of absorption lines would not be visible to an observer at the upper limit of our atmosphere, and therefore owes its origin to the oxygen in our own atmosphere.

M. JANSSEN is also of the opinion that the prominent groups A and $a$ are of terrestrial origin, and would disappear at the upper limit of our atmosphere.

There is a wide field of useful work before the Mont Blanc observers, and astronomy is again indebted to the generosity of M. BISCHOFFSHEIM, who is defraying a large part of the expense of construction and equipment. We trust that the difficulties of life on the summit may not impose very narrow limits upon the investigations to be undertaken. W. W. C.

## THE SPECTRUM OF *ALCYONE* ($\eta$ *TAURI*).

The spectrum of *Alcyone* is always classed as SECCHI'S type I, or *A*, as in the DRAPER Catalogue; that is, a spectrum containing dark (and usually rather broad) hydrogen lines. I have observed this star visually, and found the $H\alpha$ hydrogen line to be bright. It is not very intense, but in good seeing is easily visible with the 36-inch telescope. There is a narrow dark line in contact with it on the side of smaller wave-length, and possibly a still finer one on the side of greater wave-length. I do not think this line can be seen with a 12-inch telescope.

A photograph of the portion of the spectrum between $H\beta$ and K shows $H\beta$, $H\gamma$, $H\delta$ and H to be dark, as was expected, and a few additional fine dark lines. W. W. C.

September 7, 1893.

## WAVE-LENGTHS OF THE PRINCIPAL LINE IN *NOVA AURIGÆ'S* SPECTRUM.

The table below contains all the wave-lengths of the chief nebula line in *Nova Aurigæ's* spectrum obtained thus far, together with the corresponding velocities of approach in miles per second:

| Date. | W.-L. | Velocity. |
|---|---|---|
| 1892, Aug. 20 | 5003.6 | −128 |
| 21 | 3.7 | 125 |
| 22 | 3.7 | 125 |
| 23 | 3.1 | 147 |
| 30 | 2.4 | 173 |
| Sept. 3 | 2.4 | 173 |
| 4 | 1.9 | 192 |
| 6 | 2.1 | 184 |
| 7 | 1.9 | 192 |
| 15 | 2.2 | 180 |
| 22 | 2.5 | 169 |
| Oct. 12 | 3.6 | 128 |
| 19 | 3.8 | 121 |
| Nov. 2 | 4.4 | 99 |
| 3 | 4.7 | 87 |
| 9 | 4.4 | 99 |
| 16 | 4.9 | 80 |
| 17 | 4.9 | 80 |
| 24 | 4.5 | 95 |
| 1893, Feb. 10 | 6.2 | 30 |
| 14 | 6.1 | 33 |
| 27 | 5.7 | 51 |
| Mch. 26 | 5.2 | 69 |
| May 9 | 5.3 | 65 |
| Aug. 6 | 6.0 | 41 |
| Sept. 1 | 5.6 | 55 |
| Oct. 10 | 6.1 | −36 |

W. W. C.

## RESEARCHES UPON COMET 1889, V.

Dr. CHARLES LANE POOR'S mathematical discussion of the orbit of Comet 1889 V, recently published in *The Astronomica Journal* shows it to be an orbit of unusual interest. This come

was discovered by BROOKS in July, 1889. Dr. CHANDLER found that it was then moving in a small elliptic orbit whose period was a little more than seven years, and pointed out that in 1886 it passed so closely to the planet *Jupiter* that its orbit must have been radically changed. By eliminating the action of *Jupiter* in 1886, Dr. CHANDLER concluded that *before* 1886 the comet moved in a large ellipse whose period was about twenty-seven years. It also appeared that there must have been a very close approach to *Jupiter* in 1779. Now LEXELL'S periodic comet 1770 II was not seen *after* the year 1770, presumably for the reason that in 1779 it approached *Jupiter* more or less closely, and its orbit probably underwent considerable change. Dr. CHANDLER compared the orbit of the lost LEXELL comet *after* 1779 with that of Comet 1889 V *before* 1886, and found "an overwhelmingly strong presumption in favor of the identity of the two comets."

Dr. CHANDLER'S interesting results were published in November, 1889, a year before the comet was lost to sight. Dr. POOR'S computations are based upon the completed observations.

In regard to the near approach of the comet to *Jupiter* in 1886, Dr. POOR finds that "the comet not only passed through the system of *Jupiter's* satellites, but it actually passed within the orbit of the first satellite, whose mean distance is 5.93 radii of the planet. * * * We are safe in saying that the comet passed the center of *Jupiter* at a distance not greater than 3.63 and not less than 1.00 radii of the planet. In other words, the center of the comet may have touched the surface of *Jupiter*, and it certainly approached that surface to within 2.63 radii of the planet, or only 112,300 miles. Even this latter is a very small quantity.

"For the most probable hypothesis, * * * the comet was 2.65 days within the system of *Jupiter's* satellites, and during this time it made nearly a complete circuit about the planet, passing over an arc of 313° of longitude. The comet entered the Jovian system in longitude 118° on July 18.77, passed the planet on July 20.10 at a distance of only 2.28 radii, and July 21.43 left the system in longitude 71°. During this time it must have collided with one or more of the satellites."

Dr. POOR finds that the period of the comet, previous to 1886, was between the limits 32.60 and 30.17 years. Now LEXELL'S lost comet was disturbed by *Jupiter* in 1779 in the

same part of *Jupiter's* orbit that the planet and Comet 1889 V were in July 20, 1886. The interval between these disturbances is 107 years. The period of Comet 1889 V being about 31 years, which is not an aliquot part of 107, that comet could not have been near *Jupiter* in 1779, unless it suffered other and serious disturbances in the intervening years. Such disturbances did take place in 1827 and 1791, but they were of such a nature as to leave very serious doubts whether the comet was near *Jupiter* in 1779, a condition absolutely necessary to establishing the identity of the two comets.

Dr. POOR concludes that the vexed question of identity cannot now be answered, but we must await further observations of the comet at its reappearance in 1896. He promises in another paper to discuss the question of the disruption of the comet while in *Jupiter's* system, and of the possibility of a portion of it being permanently drawn into the system to form a new satellite.

W. W. C.

## THE PARALLAX OF THE PLANETARY NEBULA DM. + 41°, 4004.

Dr. J. WILSING, of the Potsdam Astro-Physical Observatory, has determined the parallax of WEBB'S planetary nebula DM. + 41°, 4004 by the photographic method. From June, 1892, to June, 1893, 102 exposures of eight minutes each were made on the region of the nebula. The distances of the nebula from two eleventh magnitude stars were accurately obtained from all the plates, and a combination of the data gave as the most probable value of the parallax of the nebula relative to one of the stars

$$\pi = - 0''.08;$$

and relative to the other star

$$\pi = - 0''.17.$$

The fact that the relative parallax comes out negative indicates that the distance of the nebula from our solar system is probably greater than that of the two eleventh magnitude comparison stars.

This is the first nebula parallax to be investigated photographically. Dr. WILSING'S paper is published in *Astronomische Nachrichten*, No. 3190.

W. W. C.

### Comet *c* 1893.

This comet was discovered on the morning of October 17, by Mr. William R. Brooks of Smith Observatory, Geneva, N. Y., in the constellation *Virgo*. It was observed here the next morning, and is still under observation. For several days after discovery it increased rapidly in brightness, until, on October 21, it was nearly visible to the naked eye, and its tail was easily traced two or three degrees, even with the bright zodiacal light for a background. Since then it has grown somewhat fainter, but is still a conspicuous object in a telescope.

Professor Porter, of Cincinnati Observatory, has computed an approximate orbit of the comet. It was nearest to the Sun about September 21, at a distance of 0.83 of the Earth's mean distance from the Sun.

Thus far the comet has moved eastward about $1^m\ 30^s$ per day, and northward about 45′ per day. It promises to remain in good position for observing for a considerable time. W. W. C.

November 11, 1893.

### New Quarters for Astronomers at Mount Hamilton.

A contract has been signed providing for the erection of two brick houses to be used as quarters for Messrs. Barnard and Campbell. The houses are to be finished by July 1, 1894. The sites selected are about 1000 feet south of the Great Dome.

E. S. H.

### Erratum in *Publication* 31.

Page 141, line 31, for "fourth quadrant" read "third quadrant."

## Minutes of the Meeting of the Board of Directors, held at the Chabot Observatory, November 25, 1893.

President Molera presided. A quorum was present. The minutes of the last meeting were approved.

The following members were duly elected:

List of Members Elected November 25, 1893.

| | |
|---|---|
| Mr. Walter Cramp | 1229 North Broad Street, Philadelphia, Pa. |
| Mr. Fr. Dienelt | Loda, Iroquois Co., Illinois. |
| Miss Elsie Hadley† | State Normal School, Valley City, North Dakota. |
| Mr. Andrew P. Henkel | 317 Locust St., Cincinnati, O. |
| Dr. S. P. Langley | Director Smithsonian Institution, Washington, D. C. |
| Prof. F. P. Leavenworth | University of Minnesota, Minneapolis, Minn. |
| Mr. Sam C. Phipps | Millbrae, Cal. |
| Mr. John Jay Pierrepont | Brooklyn, Kings Co., N. Y. |
| Mr. C. A. Spreckels | San Mateo, Cal. |
| Mrs. C. A. Spreckels | San Mateo, Cal. |
| Mr. Rudolph Spreckels | Palace Hotel, S. F., Cal. |
| Miss Gertrude Stanford | 1218 Oak St., Oakland, Cal. |
| Mr. J. W. Ward | 271 Bourke Street, Sydney, New South Wales. |
| Mrs. E. M. White | Framingham, Massachusetts. |

A committee of two, Messrs. Pierson and Campbell, was appointed to ascertain the number of institutions on the exchange list, from whom the Society receives publications, and to report at the next meeting regarding a revision of the list of corresponding institutions.

It was, on motion, *Resolved*, That in the death of the Hon. Alexander Montgomery, the generous founder of our library and a life member of this Society, our organization has lost a cherished associate and a sincere patron of astronomical science.

A committee of two, Messrs. Pierson and Ziel, were instructed to present to the next meeting of the Board a brief history of the career of Hon. Alexander Montgomery, deceased, and of his benefactions to this Society.

Adjourned.

## Minutes of the Meeting of the Astronomical Society of the Pacific, held at the Chabot Observatory, in Oakland, November 25, 1893.

President Molera took the chair. The minutes of the last meeting were approved.

The Secretary read the list of new members elected at the Directors'

† Membership to take effect January 1, 1894.

meeting. It was voted that the thanks of the Society be returned to the officers of the School Department and to Mr. BURCKHALTER, for the use of the Chabot Observatory.

The following papers were presented:

1. On the Stars with Bright Lines in their Spectra, by Professor CAMPBELL, of LICK Observatory.
2. Variation of Terrestrial Latitudes, by Professor HUSSEY, of Stanford University.
3. Charts of Stars for Magnitude—Comparisons, by Mr. R. H. TUCKER, Jr., of LICK Observatory.
4. A Preliminary Note on a Mechanical Theory of Comets, by Professor SCHAEBERLE, of LICK Observatory.
5. Reports on the Solar Eclipse of October 9, from Mr. BURCKHALTER, Mr. HARMON, Professor TAYLOR, and from the LICK Observatory.
6. The Bright Streaks on the Moon, by Professor SCHAEBERLE of LICK Observatory.

The Chairman then introduced Professor W. W. CAMPBELL, of the LICK Observatory, who delivered a lecture on "Stars with Bright Lines in their Spectra," illustrated by fifty-six lantern slides, the majority of which were photographs of star spectra made by him with the 36-inch equatorial of the LICK Observatory, with exposures ranging from ten minutes to four hours.

The meeting then adjourned.

## OFFICERS OF THE SOCIETY.

E. J. Molera (40 California Street, S. F.), . . . . . . . . . *President*
Wm. M. Pierson (Mills Building, S. F.), W. J. Hussey (Leland Stanford Jr. University, Palo Alto, Cal.), . . *Vice-Presidents*
W. W. Campbell (Lick Observatory), . . . . . . . . . *Secretary*
F. R. Ziel (410 California Street, S. F.), . . . . . *Secretary and Treasurer*

*Board of Directors*—Messrs. Alvord, Burckhalter, Campbell, Holden, Hussey, McConnell, Molera, Pierson, Schaeberle, Von Geldern, Ziel.

*Finance Committee*—Messrs. Pierson, McConnell, Ziel.

*Committee on Publication*—Messrs. Holden, Campbell, Yale.

*Library Committee*—Messrs. Pierson, Von Geldern, McConnell.

*Committee on the Comet-Medal*—Messrs. Holden (*ex-officio*), Schaeberle, Burckhalter.

## OFFICERS OF THE CHICAGO SECTION.

*Executive Committee*—Ruthven W. Pike.

## OFFICERS OF THE MEXICAN SECTION.

*Executive Committee*—A. Anguiano (Chairman), Camilo Gonzalez, Francisco Rodriguez Rey, Agustin Aragon.

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## NOTICE.

The attention of new members is called to Article VIII of the By-Laws, which provides that the annual subscription, paid on election, covers the *calendar* year only. Subsequent annual payments are due on January 1st of each succeeding calendar year. This rule is necessary in order to make our book-keeping as simple as possible. Dues sent by mail should be directed to Astronomical Society of the Pacific, 819 Market Street, San Francisco.

It is intended that each member of the Society shall receive a copy of each one of the *Publications* for the year in which he was elected to membership and for all subsequent years. If there have been (unfortunately) any omissions in this matter, it is requested that the Secretaries be at once notified, in order that the missing numbers may be supplied. Members are requested to preserve the copies of the *Publications* of the Society as sent to them. Once each year a title-page and contents of the preceding numbers will also be sent to the members, who can then bind the numbers together into a volume. Complete volumes for past years will also be supplied, to members only, so far as the stock in hand is sufficient, on the payment of two dollars to either of the Secretaries. Any non-resident member within the United States can obtain books from the Society's library by sending his library card with ten cents in stamps to the Secretary A. S. P., 819 Market Street, San Francisco, who will return the book and the card.

The Committee on Publication desires to say that the order in which papers are printed in the *Publications* is decided simply by convenience. In a general way, those papers are printed first which are earliest accepted for publication. It is not possible to send proof sheets of papers to be printed to authors whose residence is not within the United States. The responsibility for the views expressed in the papers printed rests with the writers, and is not assumed by the Society itself.

The titles of papers for reading should be communicated to either of the Secretaries as early as possible, as well as any changes in addresses. The Secretary in San Francisco will send to any member of the Society suitable stationery stamped with the seal of the Society, at cost price, as follows: a block of letter paper, 40 cents; of note paper, 25 cents; a package of envelopes, 25 cents. These prices include postage, and should be remitted by money-order or in U. S. postage stamps. The sendings are at the risk of the member.

Those members who propose to attend any or all of the meetings at Mount Hamilton during the summer should communicate with "The Secretary Astronomical Society of the Pacific" at the rooms of the Society, 819 Market Street, San Francisco, in order that arrangements may be made for transportation, lodging, etc.

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AND

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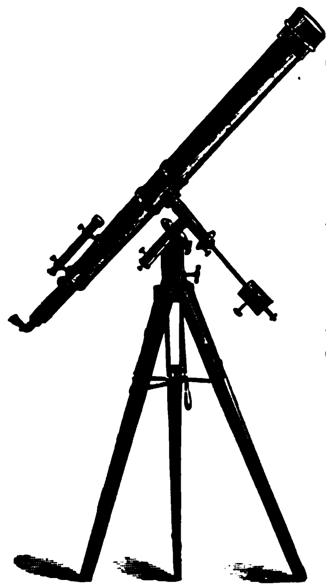



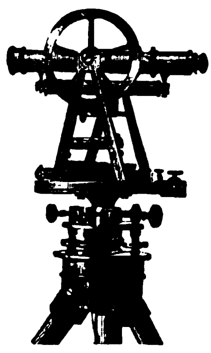

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**TUESDAY, AUGUST 8, 1893.**

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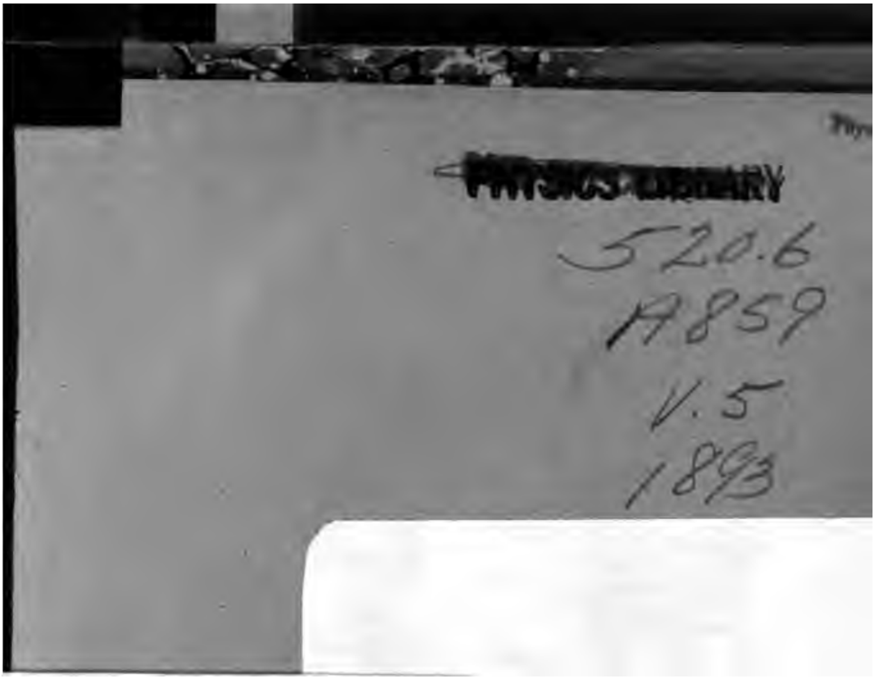
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